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THE DEFENCE OF INTELLECTUAL FREEDOM

THE extent to which freedom is a vital issue to-day is illustrated by the discussion in Britain provoked by the publication of the White Paper on the Political Activities of Civil Servants, and more especially by the effect of secrecy requirements on the publication of research in nuclear physics. It is reflected in the discussion as to the position of the private foundation or voluntary organization in the endowment of scientific research, which has arisen in recent years on the reports of the Nuffield Foundation, the Rockefeller Foundation, the Carnegie Trust and Lord Beveridge's study of "Voluntary Action". It is to be seen, too, in the interest which has been taken in the loyalty inquiries in the United States, among both the employees of that Government and among the employees of the United Nations. Scientists indeed have been particularly interested in some of the results of what is popularly termed 'McCarthyism' or 'witch-hunting', and have welcomed the dignified and firm defence of academic freedom which individuals and universities have made.

That defence led last March to the issue by the Association of American Universities of a statement on "The Rights and Responsibilities of Universities and their Faculties" (obtainable from the Department of Public Relations, Princeton University, Princeton, N.J.). The statement was adopted unanimously by the heads of thirty-five of the leading universities in the United States, and its forthright championing of the free mind and free inquiry, and of the right and duty of candour and freedom of speech, is far from being the platitudinous verbiage it might have seemed a generation or two ago. While it is pointed out that academic freedom never implies freedom from criticism, firm protest is made against the application of special loyalty tests to university faculties. Such discrimination harms the individual—and even more the university—and the whole course of education by destroying faith in the ideals of university scholarship.

When the powers of legislative inquiry are abused, however, the remedy is not to be sought in non-co-operation or defiance: the Association concludes that it is to be sought through the normal channels of informed public opinion. This conclusion, moreover, is of interest in another connexion which is deeply perturbing most American scientists and technologists, and which is being followed with close interest by their colleagues in Britain. The sudden dismissal of Dr. Allen V. Astin from his post as director of the National Bureau of Standards raised doubts as to whether or not high technical positions in the Government service would be subjected to political pressure whenever there was a change of administration. As a result of the storm raised in the Bureau of Standards itself, in the scientific press and elsewhere, Dr. Astin has now been temporarily reinstated; but the reflexions on the professional integrity of the Bureau and on Dr. Astin's own integrity and competence do not appear to have been withdrawn, although in the meantime the

Massachusetts Institute of Technology has reported in exactly the same terms as the Bureau in its circular on battery additives which the United States Secretary of Commerce ordered to be withdrawn.

It seems unlikely in the circumstances that any outstanding scientist whose attainments command national respect will accept the position of director in succession to Dr. Astin, and American scientists are concerned that the dissatisfaction in the Bureau of Standards is likely to spread to other government agencies in the United States employing scientists. They argue that if any government agency should be immune from outside pressure of any kind it is the Bureau of Standards, which is the leading adviser on scientific matters to industry as well as to government agencies. The institution in Great Britain which most resembles the Bureau is the National Physical Laboratory, and British scientists will readily appreciate the argument that an institution concerned with testing and evaluating for the Government thousands of products and processes cannot function properly if it is subject to political or other influence.

Whether or not it is too much to maintain that scientific research is bound to suffer from any departure from the Bureau's established policy of rendering an impartial judgment on any matter with which it is confronted, the episode illustrates that professional freedom and integrity are of practical and not merely theoretical interest to-day. That much was, of course, brought out in Prof. A. Macbeath's "Plea for Heretics" at the British Association meeting in Belfast last September, and such considerations have prompted the publication during the past two or three years of such books as Prof. Gellhorn's "Security, Loyalty and Science", Mr. Barth's "The Loyalty of Free Men" and the anthology entitled "Primer of Intellectual Freedom". These, however, are only a few of the recent contributions to the discussion, and they have already been referred to in these columns. Two other sharply contrasting books may be mentioned here; they make no attempt to examine the present situation or the policies now being pursued by governments, universities, professional bodies and democratic institutions; but they are of special interest for the light they throw on the principles and practices which may arise out of the present situation.

The first of these books, J. M. Brewer's "Wellsprings of Democracy"*, is severely practical or pragmatic. Its approach is not theoretical or philosophical, as its title might seem to suggest, but is indicated rather in the sub-title, "Guidance for Local Societies". It is concerned with procedure, with the way in which democratic associations, of any kind or on any level, work, the demands they make on their members, and the conditions for successful functioning; whether in a business organization, a works council or board meeting, a scientific or a local society. It is intended to assist people to participate in the business of such a democratic organization and also to make them aware of the pitfalls and the dangers which hinder co-operation and which, if unchecked, may transform a democratic association into an autocratic or moribund one. Save in one chapter, however, the philosophical aspect is never touched and, though strictly practical, the book makes dry reading and lacks the vision and vitality of books like Sir Ernest Barker's "Reflections on Government" or Lord Lindsay's "The Modern Democratic State" or his lectures on "Religion, Science and Society in the Modern World".

Mr. Cranston's book* is of the opposite type. This new analysis of freedom is concerned with the theory rather than the practice of freedom. It begins with a brilliant analysis of the meaning of freedom which clearly and forcefully dispels the ambiguities in the use of the word and the fallacious reasonings frequently based on these ambiguities. In this part alone the book makes an outstanding contribution to current discussions on freedom, and should prevent them from becoming as sterile and impractical as they often are. Ambiguity, he insists, is only avoided if, like the late President Roosevelt, we define freedom as freedom from or freedom for some specific purpose or object.

This really excellent essay on precision in the use of words deflates the frequent pretentiousness of metaphysicians and obscurantists as well as of politicians; but it equally exposes the real difficulties and incoherences in the thought and tradition of liberalism, both in the academic and the political fields. The ambiguity of liberalism is examined more fully in the second part, the successive chapters of which deal with liberalism as it is understood in Great Britain, in France, in Germany and in the United States. Here again is a most useful contribution to clear thinking and a solvent of misunderstandings when, for example, British and American scientists are discussing such matters as the defence of professional or academic freedom in the context of the particular society of which they are members.

When we come to the third part, however, Mr. Cranston turns determinedly into the philosophical field and examines the eternal problem of determinism and free will. Here his lucidity of exposition does not forsake him, and he can still be read with ease and pleasure by the lay reader; but this part is not so clearly related to what has gone before, nor is it of the same interest and relevance for the great practical debate of our times. The great value of the book lies rather in the insistence that the word 'freedom' is not completely descriptive, and its warning against dangers inherent in the emotive meanings or connotations of laudatory words of this kind—a warning to be heeded by the scientific writer, whether he is dealing with some aspect of freedom as it affects science, or with some aspect of science as it may affect technology or society. Without disparaging the third part of the book as a philosophical disquisition—though Mr. Cranston's verdict against determinism and in favour of the

* Wellsprings of Democracy: Guidance for Local Societies. By John M. Brewer. Pp. xii+232. (New York: Philosophical Library, Inc., 1952.) 4.50 dollars.

* Freedom: a New Analysis. By Maurice Cranston. Pp. viii+177. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1953.) 12s. 6d. net.

libertarian analysis of the freedom of will includes reservations—it disappoints the reader who may well have been led by the excellence of the first two parts to expect an equally lucid exposition of the nature of the free society and the conditions on which such a society can exist.

Such an exposition Mr. Cranston could undoubtedly give us, and his indication of the contribution which the philosopher could make to clear thinking and constructive debate induces the hope that he may still attempt it. He has shown us plainly that, without clear ideas of the meaning of freedom, confusion and misunderstanding are inevitable and to that extent stimulate the careful examination which should form the basis for any firm defence of academic freedom and opposition to the invasion of civil rights, both in the Civil Service and in technical fields like that of atomic energy. But on the issue of responsibility and the choice of freedom, Mr. Cranston says little, though his clarity of thought and his avoidance of jargon suggest that he could write much that would help the layman as well as the professional philosopher.

"Parliamentary institutions, with their free speech and respect for the rights of minorities, and the inspiration of a broad tolerance in thought and its expression—all this we conceive," said Her Majesty the Queen, in her Coronation Day broadcast, "to be a precious part of our way of life and outlook." If all this is to be cherished and practised, much more is required than the formulation and observance of the appropriate rules and organizations with which Mr. Brewer's book is concerned. We must have clear understanding of what we mean by freedom in the political and social context of our time, and of the conditions under which those freedoms which we wish to cherish are best nourished. Our defence of intellectual freedom—the right of investigation and of communication in whatever aspect—can only be securely based on a like clear understanding of the whole situation, and its philosophical, no less than its practical, implications.

FROEBEL'S INFLUENCE ON ENGLISH EDUCATION

Friedrich Froebel and English Education
By P. Woodham-Smith, J. P. Slight, O. B. Priestman, H. A. Hamilton, N. Isaacs. Edited by Evelyn Lawrence. Pp. 248+12 plates. (London: University of London Press, Ltd., 1952.) 20*s*. net.

THE purpose of this book, to make a faithful record of the development of Froebel's educational concepts in relation to English education over the past century, is carried out with admirable objectivity. As the story unfolds, it is brought home to us that much which we tend to think of as specifically the pressing problem of our times is inherent in progressive education at all times.

The expansion of Froebel's ideas is traced through chance factors of ideas, social problems and, above all, the type of disciple he inspired. Froebel's own ardent mind, always seeking hidden connexions, underestimating his powers of suggestion, impatiently generalizing from insufficient data and imploring educationists to show greater respect for childhood, fired the imagination of the singularly fine quality of women who were struggling for emancipation all over the world; the German Baroness von Marenholtz, the Indian Pundita Ramabai, the headmistresses of such outstanding schools as Notting Hill and Croydon High Schools and the North London Collegiate, the stepdaughter of the first Mistress of Girton and many others incorporated the idea of the emancipation of children in their own campaign. Outstanding men, such as Dickens, gave the idea critical and appreciative attention. Froebel's enthusiasm had first been roused by the international group of young men he met in Pestalozzi's school, and the international appeal of the ideas resulted in kindergartens opening in countries far beyond Europe; moreover, contact was maintained between the work in different countries—for example, the British interest in the American developments under Dewey.

The story is told of Froebel's pioneering, how he saw play as an activity as purposeful as work and revolutionized the child–adult relationship, supplanting repression with encouragement and making fellow teachers and learners of both. His reason for concentrating on the very young was merely that he saw this age, denied the sacred right of discovery, as the weakest link in the vital chain of development. He begged for no slavish following of his suggestions and, in order to minimize this, had to attend to the training of educators. The story is told of the ceaseless fight for training teachers in freedom, in order to preclude misuse of practice through misconception of principles, and how this led to a much finer quality of teacher for the very young than had previously been thought necessary. Although certain restrictions in government schools meant that the kindergartens had to be privately run, the spiritual basis of the work and the sense of vocation in the training convinced the Froebel teachers that their ideas concerned all children, and the story is laced with accounts of out-of-school activities and club work. Societies had to be formed to maintain standards, encourage pioneering and prepare public opinion.

The chapter on Froebel's religious philosophy is tackled on too narrow a field, since it fails to throw light on the international inter-religious appeal of his spiritual concepts. It is generally accepted that he was an unsystematic philosopher and that he, like some of the earlier psychoanalysts, mistakenly believed childhood tensions could be entirely eliminated; but there is grandeur in this misconception when we realize that it was arrived at through surmounting the most terrible tensions in his own childhood, and we have far to go before we have eliminated unnecessary suffering in children.

The final chapter is one of the finest expositions yet written of the principles underlying modern educational practice. The style is clear and temperate, and the survey, though brief, is very extensive. Froebel's principles are formulated systematically, and attention is directed to recent results from studying children, which are related to our changed picture of the world. In conclusion, there is a thought-provoking study of the nature of unresolved clashes in ultimate philosophies and a new approach to the problem of freedom of thought which virtually compels us to take on the responsibility of granting children their right to be prepared for the responsibility of freedom. If we act quickly, we may still be in time to save the human race by emancipating the children.

P. M. PICKARD

"FLYING SAUCERS"

Flying Saucers

By Prof. Donald H. Menzel. Pp. xii+319. (London: Putnam and Co., Ltd., 1953.) 21*s.* net.

THERE is a deep-rooted human instinct to regard as supernatural anything the cause of which is not immediately obvious, especially phenomena in the heavens. In early days there were the gods, either manifesting their anger in the thunderbolt or warning humanity of impending tragedy by comets or other portents. As successive phenomena received natural explanations, the supernatural began to give place to the superscientific, and in place of gods we have visitors from other worlds. Prominent among these are the 'flying saucers'—space ships of a mysterious race called 'saucerians'.

The story of 'flying saucers' begins on June 24, 1947, when a business man on a private flight in Washington State saw "a chain of saucer-like things at least five miles long, swerving in and out of the high mountain peaks. They were flat like a piepan and so shiny they reflected the sun like a mirror. I never saw anything so fast". Publication of this story in the Press was quickly followed by other reports, and when the U.S. Air Force began an official investigation, the great American public soon joined in. Saucers were seen on every hand, by day and night, from the ground and the air, at all levels and even landing. Between 1947 and July 1952, no fewer than 1,157 'saucers' were recorded. It was high time that a level-headed scientist investigated, and Prof. D. H. Menzel, professor of astrophysics at Harvard, was well qualified for a one-man jury. His book, though not very systematic, is thorough, and he adjudicates on a large number of reports, in many cases after personal interview with the witness.

Many of the descriptions are so disguised by hasty examination, preconceptions, or subsequent exaggeration that it is hard to say what was actually seen; but on the whole, 'flying saucers' may be classified into three groups: real but natural phenomena, man-made objects, and hoaxes. The natural phenomena include a wide variety: stars and planets; will-o'-the-wisps; electrical phenomena such as auroræ, St. Elmo's fire and possibly the little-understood ball lightning; sun dogs, mock suns and mock moons and other phenomena due mainly to ice crystals; peculiar cloud formations; and 'Foo fighters' or small whirls of ice crystals formed by the wings of a plane—one pilot reported a fight with one! The author thinks that many saucers, especially those seen from moving cars and seeming to skim the earth's surface, are simply mirages of distant peaks, and he devotes a long appendix to the theory of mirages.

Among man-made 'flying saucers' there are almost certainly weather balloons, but also such things as searchlight rings on cloud, which of course move about with incredible speed when the beam shifts. Then there are the 'galloping ghosts' of radar, due simply to the mechanics of that form of super-vision.

Finally, hoaxes. In 1938 a radio adaptation of H. G. Wells's "War of the Worlds" was taken as truth by at least a million listeners, some of whom actually saw the battle or smelt the smoke. That matter was soon cleared up; but the "little men from Venus" who, as described by a lecturer at the University of Denver, actually came out of a saucer, are not quite dead yet.

Although there remain a few reports which cannot be fitted into any known category, the author is firmly of the opinion—with which most thinking people will agree—that whatever they were, they were not visitors from the stars, and he supports this with a brief survey of the conditions which render civilized life, on the planets at least, highly improbable. 'Flying saucers', under other names, have been always with us, as angels and heavenly hosts, which survived even to the 'angels of Mons', and later, when the possibility of directed flight first arose, as wonderful airships (that is, lenticular clouds). It is unlikely that readers of *Nature* have ever believed in flying saucers as interplanetary visitors; but they will find this book well worth study for its store of information about curious natural phenomena, as well as for its entertainment value.

C. E. P. Brooks

"THE MERCK INDEX"

The Merck Index of Chemicals and Drugs

An Encyclopedia for the Chemist, Pharmacist, Physician and Allied Professions. Sixth edition. Pp. xiv+1167. (Rahway, N.J.: Merck and Company, Inc., 1952.) 7.50 dollars; thumb-indexed, 8 dollars.

THIS attractive compendium will be familiar to many chemists, pharmacists and medical men through its earlier editions. First published in 1889, it has undergone a series of metamorphoses and modernizations. The fifth edition was published in 1940. The present edition is already assured of a wide circulation, for nearly fifty thousand copies are said to have been ordered prior to publication. There are more than eight thousand descriptions of individual substances, more than two thousand structural formulæ, drawn to conform to the Ring Index, and about twenty thousand names of chemicals and drugs—these include many trade names with their equivalents. Although primarily intended as a work for rapid reference, browsing in the new "Merck Index" is a fascinating and stimulating exercise.

Appendixes occupy some hundred and forty pages and include a list of more than three hundred 'name' reactions with descriptions and references; a table of radioactive isotopes with their half-life periods, types of radiations and medical uses; and a list of dyes permitted in the United States for colouring foods, drugs and cosmetics.

The choice of compounds selected for inclusion in the "Index" seems somewhat arbitrary. There is a wide range of natural and synthetic drugs, and for these chemical descriptions are given, with literature references to their determinations of structure and methods of synthesis. Toxicities and medical and veterinary uses are briefly indicated. Many natural products having no established therapeutic applications are also included, together with a variety of purely synthetic products having no connexion with medical usage. These last probably represent a survival of the design of the first edition, which included in its title "a summary of whatever chemical products are to-day adjudged as being useful in either medicine or technology". Non-medicinal substances not of natural occurrence described in the "Index" include the monochloronaphthalenes, Cleve's acids, decalin and tetralin, and polycyclic

aromatic hydrocarbons such as chrysene, picene, pyrene and 3 : 4-benzpyrene. Entries relating to an interesting series of siloxanes are also dispersed through the pages. In some cases the reason for inclusion is not apparent. Thus, there is a relatively lengthy entry relating to the synthesis and properties of 9 : 10-dimethyl-1 : 2-benzanthracene, but without any reference to its high carcinogenic activity, which is the main reason for interest in this compound.

Not all the entries are completely up to date, and when a seventh edition is prepared the opportunity should be taken to correct a few errors and repair omissions. For example, the tentative structure attributed to β-erythroidine has now been superseded. The structures given for caryophyllene and solasodine are out of date and have been corrected by recent work. The functional substituents of the tropolone ring of colchicine are incorrectly placed. The latest reference given for corynanthine is dated 1911. There should be mention of more recent work, and especially of the structural relationship of corynanthine to yohimbine. Again, allusion should be made to recent work on the structure of rubijervine, the latest reference to which is dated 1890. Out-of-date structures are also assigned to puberulic and puberulonic acids, and there is no mention of the other natural tropolones, except colchicine. These examples, selected at random, serve to emphasize how difficult it is to keep abreast of modern developments in such a wide field as is covered by the "Merck Index". J. W. Cook

THE LONDON MINT

The Mint

A History of the London Mint from A.D. 287 to 1948. By Sir John Craig. Pp. xviii+450+16 plates. (Cambridge : At the University Press, 1953.) 70*s*. net.

THE author, a former deputy-master and comptroller of the Royal Mint and engraver of the King's Seals, to give him his full titles, is already well known by his fascinating little study "Newton at the Mint". The present work is a more substantial piece of historical research, for which Sir John Craig has pre-eminent qualifications. Minting has been carried out in London, in any event since the time of the Roman occupation, and the account now presented extends from then to the present time. To the historian, to the economist, to the numismatist and to the technologist, this account of the activities of the Mint during these seventeen hundred or so years is of first-rate importance.

The ground covered is very wide, and it is difficult to believe that any significant aspect of the Mint's activities has been overlooked. The holiday-maker, for example, chaffing under restrictions in the amount of English currency which he may take abroad with him, can take comfort in the fact that "it was almost always unlawful from the Statute of Stepney in 1299 to take coin or precious metal out of the country without licence". The production of such coin in medieval times in a very large number of mints distributed over the whole country was gradually concentrated in London, until, in 1553, the Tower Mint became the sole source of the English coinage. Only at times such as the Civil War, when many local mints were opened to provide for the payment of troops, and during periods of intense recoinage, such as that for which Newton was responsible, were the activities of the London Mint decentralized. The difficulties under which the coinage was produced led at times to acute shortages, and even as late as the third quarter of the eighteenth century foreign coin came into Britain and circulated without let or hindrance on its bullion value. The control of the purity and weight of our coins is determined by the Trial of the Pyx, an assay which must have been instituted not later than about the middle of the thirteenth century. The practice has changed since then on many occasions, and is here described with what might almost be called affectionate care.

There is much in the treatment of immediate interest to the economic historian; particularly is this true of the output of gold and silver coin, recorded in an appendix almost year by year from A.D. 1273 in the case of silver and 1344 in that of gold.

The utilization of the best scientific minds of the day has been evident since the time of Newton himself. In one way or another Cavendish, Boulton, Watt, Graham, Roberts-Austen and Herschel, among many others, have directed or assisted the London Mint.

This outstanding piece of historical research is presented to the ordinary reader free from any suspicion of heaviness, well illustrated by plates of coins, machines, maps, medals and portraits, and admirably indexed. It represents a most important contribution to English history. F. C. Thompson

FIELD TRIALS WITH PERENNIAL PLANTS

Field Experimentation with Fruit Trees and other Perennial Plants

By S. C. Pearce. (Commonwealth Bureau of Horticulture and Plantation Crops, Technical Communication No. 23.) Pp. x+131. (Farnham Royal : Commonwealth Agricultural Bureaux, 1953.) 10*s*.

THE application of modern statistical methods to experimentation in a particular field of research frequently introduces new problems, and these in turn lead to new ideas and developments which are very often of interest to experimenters in general. For this reason the appearance of a specialized study such as that under review is usually welcome. Dr. Pearce's book presents an account of the design, practice and analysis of experiments with perennial crops. It has been written by a statistician who has had considerable experience of these subjects at East Malling Research Station.

After a brief introductory chapter, a number of experimental designs are described in Chapters 2 and 3. Most of these designs are in general use. Their main purpose is the control of positional variation. Interesting new material is provided in the sections on designs which allow thinning out of plants during the course of an experiment, and designs which allow further experiments to be carried out on the same plantations. Methods for controlling non-positional variation, which is frequently of great importance with perennial crops, are discussed in Chapter 4. The next chapter contains useful practical recommendations on the size and shape of plots, the use of guard rows, and the provision of adequate replication. A discussion of the types of design appropriate to different subjects of investigation follows.

The remainder of the book is concerned with the measurement of observations and the analysis of results. The arrangement is rather unusual in that computational details are relegated to four appendixes, where they are given in general terms. Whether readers will be able to grasp the principles underlying the least-squares methods of estimation and the analysis of variance and covariance from these appendixes remains to be seen. In Appendix 3 the method for determining variances and covariances is unnecessarily laborious, while Appendix 4 is restricted to only one particular use of the analysis of covariance, although this is not stated. The main text includes discussions of the interpretation of results, the use of transformations and the treatment of incomplete data. The final chapter is an account of the methods of measurement of perennial plants adopted at East Malling. An extensive list of references and a subject index are given at the end of the book.

Dr. Pearce has addressed his book to experimenters already possessing an elementary knowledge of statistical technique, thus leaving himself free to discuss the many points which his experience has suggested are of practical importance. Many interesting issues are raised and discussed at length; but others, particularly some of those which must arise with the development of the science, receive little attention. Thus there appears, at least to the reviewer, to be an undue emphasis on 'significant differences' which, as the discussion in Section 72 shows, are troublesome things, often more confusing than helpful. Perhaps the most disappointing feature of the book is the dismissal in little more than a page of the many problems connected with the analysis of the results of an experiment lasting several years, while the only real long-term design considered (Section 60) is full of pitfalls for the inexperienced or uncritical reader.

Sometimes the expression is rather loose. The statement on p. 55, relating to amounts of fertilizers, that "with a perennial the optimum application is changing all the time as the trees become older so there is no point in trying to determine what it is" can scarcely have been meant. Again, Section 92 contains some very curious comments on sampling methods and a formula which in its present unqualified form is obviously incorrect. Nevertheless, the book contains a great deal that should be of value to the experimenters for whom it is intended.

H. D. Patterson

PROGRESS IN NUCLEAR SCIENCE

Annual Review of Nuclear Science

Vol. 2. Edited by James G. Beckerley. Pp. x+429. (Stanford, Calif.: Annual Reviews, Inc.; London: H. K. Lewis and Co., Ltd., 1953.) 6 dollars.

THE second volume of this series is considerably more compact and homogeneous than its predecessor. For one thing, the subjects of the reviews are limited entirely to one aspect of nuclear science (physics); for another, many of the essays are not just miscellaneous collections of details of recent work, but present a clear and comprehensive picture of their subject as a whole. To a considerable extent, of course, this is dictated by the nature of the subject. Thus, the article on accelerators (Chu and Schiff) is all that one can expect it to be: a brief and interesting survey of recent developments on various machines and types of machine. Similarly, the essay on isotopes (Bigeleisen) gives fragments of information ranging from mass measurements to isotope effects in chemical kinetics. There is a certain amount of overlapping in the articles on "Nuclear Reactions induced by High Energy Particles" (Templeton) and "High Energy Fission" (Spence and Ford). "Radiation Effects in Solids" (Dienes) include a variety of electrical and mechanical properties, notably the transformation of n- to p-type germanium. The essay on "Nuclear Moments" (Feld) is concerned with the determination of moments of unstable nuclear states; and with a comparison between experiment and theory of the moments of stable states, particularly as predicted by the independent particle model. "Recent Studies in Photonuclear Reactions" (Strauch) discusses the significance of the peak which occurs in many photonuclear reactions between 10 and 20 MeV. "Subnuclear Particles" (Blair and Chew) is a condensed and useful summary, especially of the properties of pions and their interaction with nucleons. In "β-Decay Energetics", Coryell studies the applicability of the empirical nuclear mass formula to β-decay: and in "Nucleon–Nucleon Scattering", Breit and Gluckstern are concerned chiefly with the evidence for, and the explanation of, high-energy differential p—p scattering, with its constancy with angle and energy over a wide range. The essay on "Natural Radiocarbon" (Anderson) is an interesting discussion of the close agreement between the observed specific activity and the estimated production-rate from cosmic rays.

The remaining articles are rather more comprehensive in their scope. In the "Origin and Abundance of the Elements", Alpher and Herman survey the evidence for the cosmic abundance of the elements, and emphasize the close correlation between the abundance of an element and its fast-neutron capture cross-section. Various theories of the origin of the elements are presented, with emphasis on the neutron-capture theory. The article on "Angular Correlation in Nuclear Radiation" (Frauenfelder) is a concise and detailed account which makes clear the part played by the field of the electron shell (both stable, as in an ionic crystal, and unstable, as in the atomic shell during decay) in perturbing the angular correlation. The "Theory of β-Decay" (Konopinski and Langer) discusses the various interactions of the Fermi theory, and their occurrence in allowed, favoured and forbidden transitions. The "Origin of Cosmic Rays" (Biermann) is an interesting study which lays emphasis on occasional but marked bursts of cosmic radiation, such as that of November 19, 1949: the times and places of arrival, compared with the accompanying solar flare, suggest solar origin, but considerable deflexion, probably by magnetic fields, in the neighbourhood of the solar system. Theory suggests that these interstellar fields are of the order of 10^{-6} gauss and that they play a major part in the storage and acceleration of cosmic rays. Finally, there is an exceptionally clear article by Salpeter on the "Energy Production in Stars", which presents a succinct summary of the basic astrophysical data and of the methods of calculating temperature and density distribution in stars. The nature of the P—P cycle, and the experimental evidence for the carbon–nitrogen cycle, are discussed: from this, a theory can be built up which accounts reasonably well for the energy production in main sequence stars. To the reviewer, this was the most interesting essay of a good collection.

W. D. Allen

Ultraviolet Spectra of Aromatic Compounds

By Dr. Robert A. Friedel and Dr. Milton Orchin. Pp. 52+579 Spectra. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 80*s*. net.

AFTER so many publications on the theory of aromatic character, a book dealing with purely experimental data is refreshing. This work contains a collection of 579 absorption spectra, all on the same scale (one inch corresponds to 400 A. and also to one unit on the log ε scale). The loose-leaf binding allows the pages to be removed so that spectra may be compared directly. Unfortunately, the curves are not supplied with the values for the maxima, which the user must estimate by measurement of the graphs.

The collection of ultra-violet absorption curves is preceded by a short theoretical introduction of thirty-six pages. A brief account of the experimental procedure is given with reference to the American-manufactured Beckman and Cary recording spectrophotometer; the use and influence of solvents are described. The theoretical section is concerned only with classical theories and useful empirical rules. The effect of introduction of various substituents (alkyl, alkenyl, aryl, hydroxyl, amino, methoxyl, carbonyl, cyano, nitro and halogen), the effect of steric hindrance, the fine structure effect, etc., are clearly described and explained, using predominantly examples taken from the American literature. Other chapters deal with the use of absorption spectra for qualitative and quantitative analysis. All this is expertly and succinctly done.

The formula of each compound, its name, the solvent used, and the literature citations are given alongside each absorption curve. The references do not always give the name of the author who first described the quantitative spectrum of the pure compound, but relate to the most recent reproduction of the absorption curve. It would have increased the value of the work if the bibliographies had been more complete.

This well-printed collection of absorption spectra will undoubtedly attract widespread interest, and it is to be hoped that it will be followed without much delay by an improved new edition. E. CLAR

Progress in Metal Physics

(Progress Series.) Vol. 4. Editor: Dr. Bruce Chalmers. Pp. viii+403. (London: Pergamon Press, Ltd., 1953.) 60*s*.

IN recent years the output of research work in metal physics has been so great that few have been able to keep in active touch with more than a small proportion of the subjects which are now advancing so rapidly. The original purpose of the present series of books was to present authoritative reviews written with the direct object of enabling "research workers in one part of the field to remain up-to-date in other branches" (foreword to Vol. 1 reprinted in the present book). Unfortunately, those responsible for the series appear to have lost sight of its original purpose, and the present volume will be of little value to those wishing for reports enabling them to realize easily the progress made in branches of science other than their own. For this purpose the seven articles in the book are nearly all too long, and are written in such a way that only occasionally can the real progress be seen unobscured by a mass of secondary detail. The book must therefore be regarded as one which fails in the original purpose of the series; but at the same time it will be of great value to those who are so directly concerned with the subjects reviewed that they are willing to consider papers the length of which varies from 30 to 66 pages, with from 80 to 191 references. For serious study of this kind the book can be recommended; the articles are authoritative and good, except that the standard of writing is variable, and sometimes becomes little more than a collection of references or brief extracts.

The subjects dealt with are: (1) internal friction in metals (A. S. Nowick); (2) the mechanism of oxidation of metals and alloys at high temperatures (K. Hauffe); (3) gases in metals (C. R. Cupp); (4) the theory of sintering (G. A. Geach); (5) theory of dislocations (A. H. Cottrell); (6) diffusion in metals (A. le Claire); (7) nucleation (J. H. Hollomon and D. Turnbull). W. HUME-ROTHERY

A Contribution to the Theory of the Living Organism

By Prof. W. E. Agar. Second edition, revised. Pp. vi+235. (Melbourne: Melbourne University Press; London: Cambridge University Press, 1951.) 27*s*. 6*d*. net.

IN this, the second edition, Prof. W. E. Agar has maintained and elaborated his thesis of living organisms—and he means all organisms—as perceiving, experiencing subjects, capable of purposive actions, in an effort to attain limited 'hormic goals', which, however, may have very important biological consequences. With some rearrangement of his materials, the emphasis, as before, is on the essential unity of the organism, on the possibility of considering it, on grounds which are strictly scientific, as a psychophysical system, and on behaviour in terms of perception. It is evident that the author has been at great pains to state his ideas, reasons and conclusions with precision and clarity, his concluding chapter on evolution being a model of its kind. This is a work which will be read with appreciation by those who are specially interested in the philosophy of biology; but it deserves to be introduced to a much wider circle.

Science News, 25

Edited by A. W. Haslett. Pp. 128+24 plates. (Harmondsworth: Penguin Books, Ltd., 1952.) 2*s*.

THE twenty-fifth number of "Science News" maintains the standard set by the former volumes. An important article by N. W. Pirie entitled "Concepts Out of Context" examines the concepts of species, purity and efficiency and shows how fundamental errors can occur by the transference of a concept into a field in which it is inapplicable. "A sensible philosophy controlled by a relevant set of concepts saves so much research time that it can nearly act as a substitute for genius. . . . We avoid the problems which are real in adjacent fields but are pseudo in our own." There follows a good summary by J. Little of the use of radio-frequency methods in the study of atoms and molecules. D. E. Tribe writes briefly on the validity and significance of self-selection of diet in animals; and J. E. Sutcliffe on the mechanism of mineral salts absorption by plants. A more extended essay by Katharine Tansley and R. A. Weale reviews the evidence against the trichromatic theory of colour vision. Current lines of research and development in gas turbines are reviewed by J. Hodge. There is an account of progress in underwater television with interesting photographs, an article by Margaret Knight on consciousness of the brain, and a research report. W. L. SUMNER

SOME RECENT DEVELOPMENTS IN THE USE OF AIRCRAFT AGAINST FLYING LOCUST SWARMS

By Dr. R. C. RAINEY and H. J. SAYER
Desert Locust Survey Headquarters, Nairobi

STANDARD methods of locust control, against the hoppers (nymphs), are applicable during only a small proportion of the total length of the life-cycle of the locust. The need for a method of attacking flying swarms has long been realized, and aircraft operations against swarms of the red locust (*Nomadacris septemfasciata* Serv.) in flight were undertaken in Central Africa as long ago as 1934[1]. Sodium arsenite was applied from a Hercules aircraft, and evidence was obtained that some locusts were on occasion killed in flight, but substantial improvements in equipment, insecticide and tactics were clearly needed.

Laboratory and field research directed to these ends has been in progress under the auspices of the Anti-Locust Research Centre for a number of years past. Aircraft trials in the Kenya Highlands in 1944[2] provided striking evidence of the unreliability of dusting against adult desert locusts (*Schistocerca gregaria* Forsk.), the 14 per cent dinitro-*ortho*-cresol (DNC) dust sometimes killing at well under 7 lb. per acre of settled swarm, but on other occasions failing to kill at more than 50 lb./acre; at the same time, these trials directed attention to relevant problems of locust behaviour[3] and of insecticide application[4], and led to the conception by Kennedy and Toms of the 'aerial curtain' method of attacking flying swarms. Following a preliminary theoretical examination, at the Chemical Defence Experimental Establishment at Porton, of the possibilities of this method, field-trials were carried out in Kenya in 1945 against desert locust swarms, using a 2½ per cent dinitro-*ortho*-cresol in oil spray from Baltimore aircraft[5]. On one occasion a kill of some 3 million locusts was recorded following the application of 300 gallons of spray to a flying swarm; and sufficient was learnt to encourage further research on these lines.

In 1947, a specially developed 20 per cent dinitro-*ortho*-cresol in oil spray was found highly effective in operations with Anson aircraft against settled red locust swarms in Tanganyika[6]. Complete kills were obtained at a dosage of slightly more than one gallon per acre, and in a single operation lasting less than two hours some 1,200 acres were 95 per cent cleared of locusts at a dosage of 0·7 gal./acre. The success of these operations was, however, made possible by a combination of favourable terrain, unusually sluggish locust behaviour, and large, well-organized and energetic ground parties for scouting and demarcation. Gunn[7], reviewing progress up to this stage, accordingly considered that suitable ground machinery might well have been cheaper and equally effective against settled swarms in such circumstances, and directed attention to the particular need for the development of aircraft methods of attacking swarms in flight, independently of ground parties; meanwhile, work on ground machinery suitable for large-scale operations against such settled swarms and against hoppers has continued[8].

During 1949 and 1950 the desert locust plague flared up again; and the mobility of the swarms of this species (which have not infrequently been known to breed more than a thousand miles from the area in which they had developed as hoppers) has been such that opportunities for utilizing large ground machines against settled adults of this species, in the manner in which such machines are regularly and effectively used against the red locust in its outbreak areas[3], have been rare indeed. Moreover, recent experience in India[9] has further emphasized the inevitable limitations of techniques of aircraft operation dependent on ground parties for scouting and demarcation, whether against swarms or hoppers.

Following preliminary aircraft observations in 1951 on certain relevant aspects of swarm behaviour, air-spray trials against flying swarms of the desert locust were resumed in Kenya on a small scale in 1952, financed by the Colonial Development and Welfare Research Fund. The scope of these trials was limited by a shortage of swarms; but during February 7–15, 1952, some 890 gallons of insecticide were applied to four immature flying swarms in the Northern Frontier Province in twenty-one sorties by a single Auster *J/1B* spraying aircraft (Fig. 1; 48-gallon spray-load and 130 h.p. Gipsy Major 1 engine), using a second Auster *J/1* for observation and reconnaissance, without ground scouting or demarcation.

Throughout the period of operations the swarms concerned travelled consistently down-wind; on all four occasions on which both upper-wind observations and accurate successive swarm fixes were available, swarm-track was within 1°–8° of directly down the corresponding vectorial mean wind between the ground and the level of the highest locusts. The down-wind movement previously shown to be a general characteristic of major long-distance swarm displacements[10] was thus also true in detail for the hour-to-hour swarm movements recorded during these trials. It was accordingly found possible to use the local early-morning pilot-balloon observations to determine the sector to be searched for incoming swarms, and every swarm was in fact first located, by systematic air search, while still approaching base,

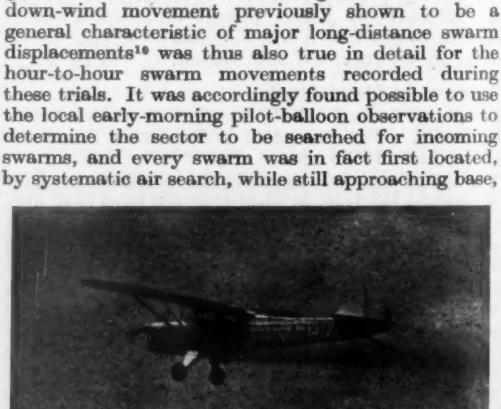

Fig. 1. Auster *J/1B* spraying aircraft passing through upper part of cumuliform swarm. Wajir District, Kenya; February 11, 1952

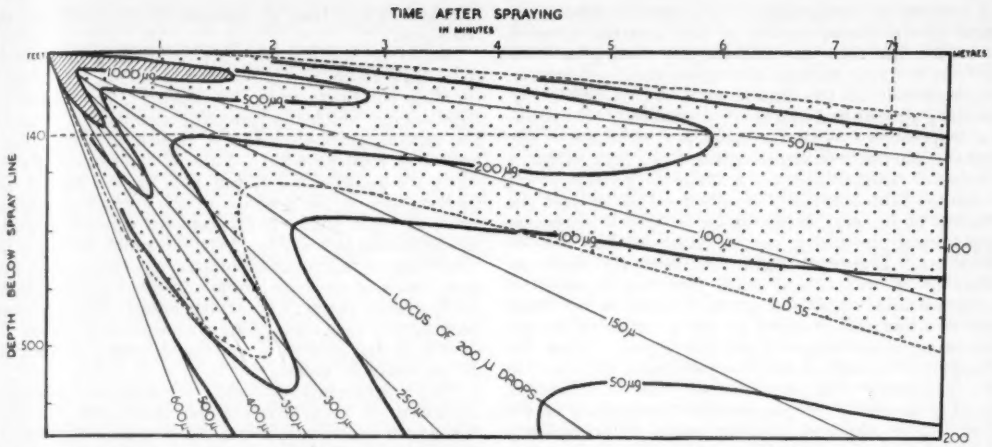

Fig. 2. Estimated dose of 20 per cent dinitro-*ortho*-cresol deposited on locusts flying at volume density of 0·1 per m.³ through single spray-sheet given by drop-spectrum and emission-rate used during February 1952

giving ample opportunities for repeated spraying operations.

Such repeated attacks by highly manœuvrable light spraying aircraft have several advantages over corresponding single operations by larger aircraft, particularly against swarms of the complex structure seen in these trials (*vide infra*). Wastage of spray, both by overdosing and by missing locusts altogether, is more easily avoided with the light aircraft, with which the task of the spray pilot is simpler and expert direction accordingly less necessary. An important further advantage of the type of aircraft used was that the cooling system of the inverted in-line engine proved particularly well adapted to deal with incoming locusts, which accumulated harmlessly at the back of the air-scoop. Serious difficulties in this respect have been experienced in the past with, for example, radial engines[1,5]. The carburettor air-intake and oil-cooler were adequately protected by specially fitted wire grilles.

The ground-speeds of the swarms were very low (1–7 m.p.h.), as a result of the intermittent nature of the flight of the individual locusts, and were substantially less than the corresponding wind-speeds (7–21 m.p.h.). In such circumstances the original 'aerial curtain' technique[11]—making successive spray-runs between fixed air-positions across the heading of the locusts—was clearly inapplicable, since practically the whole of the spray applied in this manner would reach the ground far in advance of the swarm. The alternative 'static curtain'—produced by spray-runs applied between fixed ground-positions, initially ahead of the swarm—would clearly also waste most of the spray applied in the first few runs. Furthermore, with these low ground-speeds, a static curtain would need to be maintained for an excessively long time for the whole swarm to pass through it.

Fortunately, this type of swarm behaviour (movement down-wind at a ground-speed well below the wind-speed) had been encountered and studied during the preliminary aircraft observations in 1951, and it had been decided that such swarms should be attacked by drift-spraying, using the flying locusts for demarcation; but in fact treating the temporarily settled locusts beneath, which probably represent the greater part of such swarms, as the primary target.

The most complete evidence secured during the 1952 trials on the effects of aerial spraying was provided by the small fourth swarm, initially a mile long in flight and covering an area of 300–400 acres when densely settled, which was almost completely destroyed by the application of 340 gallons of 20 per cent dinitro-*ortho*-cresol from heights of 50–400 ft. above the ground in the course of nine sorties. No rigorous assessment of mortality was possible, owing to the terrain (*Acacia – Gyrocarpus – Delonix – Boscia* dry woodland with *Commiphora – Cordia* thorn-bush, giving a total canopy approaching 40 per cent), and to the distance covered by the swarm during the spraying operations (49 miles); but the survivors which were actually seen (settled, mainly very thinly, over an area of no more than an acre) did not appear to amount to 0·1 per cent of the original swarm. Furthermore, these results were obtained under what had previously been considered unfavourable conditions, in respect both of swarm behaviour and of weather[5,12]. Thus all four swarms flew for the greater part of each day in rolling cumuliform formation, with some locusts at times up to 2,000 ft. above the ground, and many others temporarily settled beneath the swarm. Air temperatures up to 101° F. and relative humidities down to 25 per cent were encountered during the all-day operations, with vigorous convective turbulence; counting accelerometer[13] records during spraying averaged nine up-gusts per mile exceeding an equivalent vertical air velocity of 0·8 m./sec.—the terminal velocity of 220-µ drops.

Records, mainly photographic, of the density and orientation of the flying locusts, and other relevant observations taken during these trials, made it possible to assess the field-results obtained in relation to the latest Porton data[14] on spray pick-up and toxicity of dinitro-*ortho*-cresol to flying locusts under controlled wind-tunnel conditions, using the convenient method of graphical analysis developed by Sawyer[15].

The evidence thus obtained on the probable distribution and effect of the spray within a swarm is illustrated by Fig. 2, computed for the drop-spectrum used during the trials (with a mass median diameter determined by the Colonial Insecticide Research Unit as 220 µ), the corresponding emission-rate (30 gal./min. at 85 m.p.h. T.A.S.), and a swarm density of 0·1 fly-

ing locusts/m.³, which may be regarded as representative of the denser parts of the swarms sprayed in 1952. The contours indicate the dose picked up by locusts flying through the spray-sheet on courses perpendicular to the latter, at a depth below the spraying aircraft and a time after spraying corresponding respectively to the ordinate and abscissa of the appropriate point in the diagram. The area within a particular contour in such a diagram gives a direct measure of the number of locusts dosed to at least the contour figure, and, if this figure be chosen to give an appropriate mortality, an estimate of kill can be obtained. The dose figure required for such an estimate of kill is one such that the number of locusts killed under the given conditions by doses smaller than this is equal to the number of locusts surviving doses larger than this figure. Now the numbers of locusts dosed to a particular level are, at the relatively low densities so far encountered, roughly inversely proportional to the square of the dose. The required contour value is accordingly liable to be appreciably below the median lethal dose (*LD* 50 per cent); and its actual value will depend on the exact relationships between dose and mortality and between dose and relative numbers treated for the insecticide and conditions under consideration. From dose/mortality data for this particular dinitro-*ortho*-cresol formulation, applied to flying desert locusts at a representative range of drop-sizes[14], and the relationship between dose and relative numbers treated under the conditions of the trials, determined graphically from diagrams such as Fig. 2, the value appropriate to these conditions has been estimated to be about *LD* 35 per cent. This corresponds to a spray pick-up ranging from 45 μgm. per locust for 100-μ drops to 220 μgm. per locust for 350-μ drops[14]. Fig. 2 shows a *LD* 35 contour constructed in this manner, enclosing a stippled area which provides a measure of the kill.

The treatment so far assumes that all the locusts fly straight through the spray-sheet on a heading perpendicular to the latter, while the actual swarms sprayed exhibited a characteristic diversity of orientation. Sawyer's treatment may be extended to cover such behaviour by considering the extreme case of completely random orientation, with locusts flying on all possible courses. It is readily shown that such randomly orientated locusts may be expected to pick up an average dose $\pi/2$ times greater than that picked up by locusts flying perpendicularly through the same part of the same spray-sheet, but that at constant locust density the number of randomly orientated locusts passing through a given spray-sheet in unit time (or, since attenuation[11,15] can be shown to be unaffected, during the whole effective life of the spray-sheet) will only be $2/\pi$ or 64 per cent of the number which would pass through it on a perpendicular orientation. Under the conditions of the trials, orientation was not in fact completely random. Flight in groups, each of relatively uniform orientation, but with very large differences in orientation from time to time and from group to group within the swarm, such as were actually seen, would have the same effects as random orientation when the number of groups is sufficiently large and all orientations are equally represented. But indications of an occasional local predominance of either up-wind or down-wind orientations (which would have been perpendicular to the spray-sheet) suggest that conditions may be regarded as having been intermediate between the case of completely random orientation and that of orientation perpendicular to the sheet.

Before proceeding with an estimation of the kill to be expected from a particular operation, one further limiting condition must be defined: the length of time during which the spray-sheet continues to affect the swarm, through which it passes with the corresponding relative wind. This will depend not only upon the relative wind, but also on the size of the swarm, and on the position of the spray-run (always made at right angles to the relative wind) in relation to the swarm as a whole. Without much more precise recording of the progress of each operation than was practicable at the time, some uncertainty is inevitable on this latter point; but it is considered that an overall assumption that each spray-run was made across the centre of the swarm is, on the average, unlikely to be seriously in error.

The accompanying table summarizes graphical estimates of total kill for the particular operation for which information was most complete, though, from the evidence available on the density of the flying locusts, it is only possible to say that the mean volume density of the locusts sprayed is likely to have been between 0·01 and 0·1 per cubic metre. Spraying height was 140 ft. above the ground (and well below the topmost locusts), the emission-rate recorded on this occasion was 20 gal./min., and the swarm was travelling down-wind at a ground speed of 3 m.p.h. in a wind of 7 m.p.h. It was about a mile long, giving with a relative wind of 4 m.p.h. an effective duration of about $7\frac{1}{2}$ min. for each spray-sheet. With an area of about two-thirds of a square mile, a mean area density of the order of 1–10 flying locusts per square metre of plan area of the swarm, and only something like 40 per cent of the locusts in flight at once, the size of the whole swarm may be estimated as between five and fifty million locusts. With this estimate may be compared the figures for the estimated total kill resulting from the particular operation under consideration, ranging from 1·4 to 19 million (see table); the swarm was almost completely destroyed by seven such operations.

Summary of Graphical Analysis of a Single Spraying Operation

02° 01′ N., 40° 24′ E., 15·51–16·07 E.A.S.T., February 14, 1952

Graphical estimates of kill

	Orientation of flying locusts: random	Orientation of flying locusts: perpendicular to spray-sheet
For volume density of 0·1 flying locusts/m.³	$1·3 \times 10^7$	$1·9 \times 10^7$
For volume density of 0·01 flying locusts/m.³	$1·4 \times 10^6$	$2·2 \times 10^6$

Cf. total size of swarm, estimated to contain $0·5–5 \times 10^7$ locusts, and almost completely destroyed by seven such operations.

Graphical estimates of numbers dosed to 1,000-μgm. level

	Random orientation	Orientation perpendicular to spray-sheet
For 0·1 locusts/m.³	$1·2 \times 10^6$	$0·8 \times 10^6$
For 0·01 locusts/m.³	$1·2 \times 10^5$	$0·8 \times 10^5$

Cf. independent estimate of $10^5–10^6$ locusts dosed to this level, from corpse counts.

Furthermore, remains of 1,471 dead locusts, more than 99 per cent of them visibly contaminated with dinitro-*ortho*-cresol, were found at eighty sample points over an area 1,100 yd. across and extending for 2·6 miles along the track of the swarm from this spray-site; and, while both sampling and searching were severely restricted by terrain and time, it was possible from the counts made to estimate the total dead within the area of the site examined as between 10^5 and 10^6. Chemical assessment of the degree of contamination of these locusts was not practicable; but a detailed visual assessment, in conjunction with

laboratory data on the relationship between drop-size and such stain-sizes on locusts[16], indicated a mean level of contamination of the order of 1,000 μgm. per locust (incidentally suggesting a degree of over-dosing which is consistent with the fact that all these locusts must have dropped out of the swarm within about an hour after spraying). The graphical treatment gave estimates (see table) of the number of locusts dosed to at least 1,000 μgm. during this operation (corresponding to the shaded area in Fig. 2) ranging from $0{\cdot}8 \times 10^5$ to $1{\cdot}2 \times 10^6$, which may be compared with the independent estimate, given by the corpse counts, of 10^5–10^6 locusts dosed to about this level.

The graphical treatment thus gave figures which were clearly of the right order. The total kill of flying locusts, and the numbers over-dosed to a particular level, as estimated from laboratory data and theoretical considerations, both agreed, within the admittedly wide limits inherent in the nature of the field-observations, with the results actually observed. It was accordingly worth while to examine some further implications of the graphical analysis. In particular, the efficiency of this individual operation, estimated by comparing the figures given for total kill with that theoretically possible by applying the complete spray-load of 48 gallons to flying locusts in 100-μ drops at the corresponding median lethal dose of 60 μgm.[14], was only between 0·1 and 1 per cent.

In the first place, spraying-height (considered at the time only in relation to the settled locusts then regarded as the primary target) was too low (140 ft.; see Fig. 2); the spray will have reached the ground at concentrations which would still have been effective against fliers down to some 500 ft. below the aircraft. Spraying tactics clearly required modification, in order that on each spray-run the lethal zone indicated by the graphical analysis should correspond as far as possible with the main concentrations of flying locusts seen. Incidentally, even the peak ground-contamination from each spray-run during this operation is only likely to have been about ¼ gal./acre—insufficient in fact either to have given an effective kill of the more resistant settled locusts (*vide infra*), or to account for the degree of contamination of the dead locusts seen, which must accordingly have been sprayed in flight. Furthermore, the modifications indicated in spraying tactics correspond to still lower levels of ground-contamination, at which phytotoxicity effects[17], and potential dangers to man and stock (even if directly exposed), become vanishingly small.

In the second place, the kill obtained was very largely due to the smaller drops, the graphical treatment attributing some 80 per cent of the kill to drops smaller than 100 μ, which comprised less than 30 per cent of the total volume of this particular spray. While such drops are, of course, particularly vulnerable to displacement by turbulence, the grosser manifestations of turbulence may to a first approximation be expected to affect spray and flying locusts alike when the former is actually emitted among the latter (Fig. 1); and a finer spray was accordingly indicated. This point—and the greatly enhanced susceptibility attributable to flight—are strikingly illustrated by the area dosages for a 99 per cent kill, which for isolated flying locusts may be computed from the data of ref. 14 to require under ideal conditions only 0·02 gal./acre with 100-μ drops, 0·1 gal./acre with 200-μ drops, and 0·9 gal./acre with 500-μ drops, compared with the corresponding dosage of 1·1 gal./acre needed for a similar kill of completely settled locusts[18].

Thirdly, it would appear that *LD* 50 (or perhaps even *LD* 35) may be a better criterion for air-spray insecticides than the *LD* 99 figures previously used. The necessary laboratory tests on flying locusts have so far been carried out only with dinitro-*ortho*-cresol[14]; but in tests using a different (and therefore not necessarily relevant) method of application (by micro-drop syringe), γ-benzene hexachloride (BHC), for example, has been found to compare considerably more favourably with dinitro-*ortho*-cresol at the *LD* 50 than at the *LD* 99 level[19].

Further trials along the lines so indicated were financed by the Desert Locust Control Organization and undertaken the following season, using a drop-spectrum with a mass median diameter of 140–150 μ instead of 220; tactics were directed at the flying locusts instead of at the settled ones; and small quantities of a γ-benzene hexachloride concentrate were used as well as dinitro-*ortho*-cresol. Between December 30, 1952, and January 31, 1953, 3,045 gallons of concentrated insecticide were applied to fourteen small immature and maturing swarms in flight during ninety-three sorties (totalling 97 hr. flying) by two Auster *J/5G* spraying aircraft (155 h.p. Cirrus Major III engine and 78-gallon spray tank) operating from four successive bases extending over some four hundred miles across Kenya, with the assistance of a third Auster for observation and recon-

Fig. 3. Flying swarm, covering an area of some 300 acres, seen from the air; Northern Frontier Province, Kenya, January 13, 1953. This swarm was initially sighted at a distance of 40 miles; it was afterwards destroyed (and probably considerably over-dosed) by the application of 560 gallons of 20 per cent dinitro-*ortho*-cresol

naissance (representing a further 94 hr. flying), but again without ground parties for scouting or demarcation. Data were also secured on the economics of such operations; the total cost of chartering the three aircraft (terminal charges, overheads and flying charges over the whole period December 1, 1952–February 14, 1953, including 179 hr. additional experimental, reconnaissance and communications flying) was £4,400, to which should be added £1,600 in respect of the insecticide used and £2,600 in respect of the total ground expenses of the unit over this period.

The results confirmed and extended those of the previous season. Repeated air observations of four of the sprayed swarms, each initially covering 300–500 acres in flight in rolling cumuliform formation, and at times visible up to forty miles away (Fig. 3), demonstrated the striking effects of spray-rates totalling about 1 gallon dinitro-*ortho*-cresol per acre of flying swarm; all four swarms were reduced to small groups of survivors, found only with considerable difficulty and no longer worth spraying. It has incidentally since been learnt that dinitro-*ortho*-cresol spraying from aircraft is also now in use, on a substantial scale, against flying and settled swarms of *Schistocerca paranensis* Burm. in the Argentine[20].

Circumstances exceptionally favourable for ground assessment on one occasion during the Kenya trials made possible for the first time a direct assessment of the total kill resulting from a single spraying operation of this nature. Thus, following the application of 50 gallons of 11 per cent γ-benzene hexachloride to a low-flying maturing swarm between 16.50 and 17.20 hr. on January 27, 1953, over open ranching country between Nanyuki and Thompson's Falls in the Kenya Highlands, the swarm settled for the night only two-thirds of a mile beyond the spray-site, and the survivors did not move off until shortly before noon the following day. Practically the entire kill resulting from this operation accordingly took place within the 200 acres of grassland, with scattered *Acacia drepanolobium* and *Scutia myrtina*, which comprised the roosting site, instead of being scattered along many miles of thick thorn-bush as after all previous operations. Counts at 101 sampling points of 1 sq. yd. each, located to provide a valid composite sample of the whole roosting site, gave a mean and standard error of 38 ± 5·8 dead per square yard, corresponding to a total kill of 37 ± 6 million locusts. The net cost of this operation, including all flying and ground expenses of the unit over the period from the initial air-search for this swarm until the final spraying sortie, was £195. However, while between sixty and eighty tons of locusts had thus been killed at a cost of about £3 per ton by 50 gallons of insecticide containing 75 lb. of active ingredient, the actual efficiency of the operation, estimated approximately by comparing the kill obtained with that corresponding to the application of the same quantity of insecticide to the vertex of *Locusta* at the median lethal dose[19], was still only 1·5 per cent. This figure provides some indication of the scope still remaining for improvements in the technique; and, as has been indicated, effective methods are now available for the logical development of appropriate spraying equipment and tactics[15], and for the accurate assessment of new insecticide materials against flying locusts under controlled conditions[14]; also studies on meteorological factors in relation to swarm movements (refs. 10, 21, etc.) have begun to provide a rational basis for the short-period tactical forecasts of swarm movements essential for effective operations of this nature.

A fuller account of the 1951–53 trials and of the associated observations on locust behaviour is to be prepared for publication elsewhere. We should like to express our very warm appreciation of the assistance provided by our colleagues of the Desert Locust Survey and Control Organization, both in the field and at headquarters, and of the active co-operation of members of the staffs of the Anti-Locust Research Centre, the Chemical Defence Experimental Establishment, the Colonial Insecticide Research Unit (Tanganyika), the Royal Aircraft Establishment, the East Africa Meteorological Department, the Kenya Medical Department, the administration of the Northern Frontier Province, the Biochemistry Department of the University of Liverpool, Messrs. Aerial Spraying Contractors, Ltd., of Boston, Lincs, and Messrs. Pest Control, Ltd., of Cambridge, which has made this work possible.

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CHANGES IN THE MORTALITY-RATE DUE TO MYXOMATOSIS IN THE AUSTRALIAN WILD RABBIT

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RATCLIFFE and his colleagues[1] have described the violent epizootics of myxomatosis which occurred among Australian wild rabbits in the summers of 1950–51 and 1951–52. During the summer of 1952–53 there were again epizootics over the greater part of south-eastern Australia, and the rabbit population is now at a lower level than it has been since the great droughts of 1919 and 1945[2]. During the past few months, however, there have been reports from a few areas that an increasing number of affected rabbits were recovering from the disease. In this note an attempt has been made to assess the evidence for these reports, and possible mechanisms of recovery from myxomatosis are discussed.

All reports of myxomatosis in *Oryctolagus cuniculus* have emphasized the very high lethality of the disease. Recoveries are extremely rare among laboratory rabbits; but often massive doses have been used for infecting these animals. In contact infections, and inoculations with small doses of virus in 560 laboratory and English wild rabbits, Martin[3] observed ten recoveries out of 312 cases infected with one strain of the virus, three out of 248 with another strain. Bull and Mules[4] noted two recoveries in 929 wild Australian rabbits exposed to infection in a colony maintained by the regular addition of normal animals.

Accurate information upon population densities of wild rabbits in the field is difficult to obtain in Australia; but Myers[5] recorded reductions from 5,000 to 50 and 500 to 12 in two areas in which rabbits were subjected to their first exposure to the disease. Regular counts were made on standard walks. In adjacent areas it was found that about 25 per cent of the survivors gave serological evidence of previous infection. Applying this figure to the relict populations, one obtains case-mortality-rates of 99·4 per cent and 99·8 per cent, which agree closely with that recorded by Bull and Mules in the colony experiment[4].

In a few areas in which extensive outbreaks with very high mortalities had occurred in the summer of 1950–51 the performance of the disease was disappointing in 1951–52. Scattered cases occurred in the population which had built up during the winter and spring of 1952, but although the vector situation seemed adequate to ensure another violent epizootic this did not occur. Sampling of these populations and tests of the sera for antibodies to myxoma virus revealed that the majority of the surviving rabbits had recovered from infection[6]. In these areas there had been widespread infection, but a relatively small proportion of the infected rabbits had died.

During 1952–53 field investigations were for the most part concentrated in a few areas in which regular observations of the rabbit populations could be maintained by officers of the Wildlife Survey Section of the Commonwealth Scientific and Industrial Research Organization. In the summer of 1952–53 there were once again widespread and violent epizootics of myxomatosis over the greater part of south-eastern Australia. In a few localities the kill was low in spite of the observation of many diseased rabbits, and serological surveys at the end of the summer revealed the occurrence of very widespread infection. A brief description of one of these outbreaks indicates the nature of the observations[6]. Noorong Station, in the Riverina area of New South Wales, has an area of 20,000 acres. During 1950–51 and 1951–52 violent epizootics of myxomatosis occurred and the rabbit population was reduced to a very small proportion of its size prior to the introduction of the disease. In spite of some breeding during the winter the rabbit population in November 1952, when the disease appeared again, was much smaller than at corresponding periods in previous years. Just before Christmas the station manager reported that it was almost impossible to see a rabbit on the property which did not appear to be infected. By the middle of January many of the rabbits seen in the paddocks had obvious signs of recovery from myxomatosis. The kill was assessed by the station manager as 25 per cent; but this was almost certainly an underestimate. Nevertheless, the kill did not approach the figure of 90 per cent or more noted during the previous two years. The sera of the twenty-five rabbits tested after the outbreak contained antibodies to myxoma virus.

There are several possible explanations of the altered case-mortality-rates, and the position is complex because of the differing importance of the factors to be discussed in different areas.

Immunological

Myxomatosis in the European rabbit is a generalized disease associated in the late stages with an extensive rash[7]. Free antibody is rarely found in the serum of laboratory rabbits infected with virulent myxoma virus, for even with minimal inocula they usually die by the ninth or tenth day. Free antibody could be found in the sera of animals receiving small inocula of neuromyxoma virus[8], however, eleven days after infection[7]. Serial bleeds on some recovered wild rabbits obtained after the 1950–51 epizootic showed that detectable antibody persisted, at a relatively high titre, for at least eighteen months, and was accompanied by a high degree of resistance to re-infection[5].

British ecologists[9,10] believe that few wild rabbits survive under natural conditions for more than a year. If this were the case in Australia the population exposed to the annual summer epizootics might be expected to be almost universally susceptible. During the past year regular sampling of rabbit populations and serological tests have revealed that an appreciable number of rabbits which have recovered from one epizootic survive long enough to be exposed to the next one. The population count in one of the areas mentioned earlier in this article was 550 at the outset of the 1952–53 epizootic, compared with 5,000 at the same period a year earlier[11]. Sampling at the commencement of the epizootic indicated that 23 per cent of the population were survivors of the 1951–52 epizootic, and one-third of these, or 8 per cent of the total population, were immune. The pre-epizootic population of 550 might thus be considered to consist of about 500 susceptible and 50 immune rabbits. The count at the end of the epizootic, one month later, was 77, and serum sampling of a nearby area at this time showed that all the remaining rabbits had antibodies to myxoma virus. Forty per cent of these were rabbits more than a year old. Thus there was a population reduction of 500 susceptible to 46 recovered rabbits, that is, a 92 per cent case-mortality-rate. This may be compared with the figure of 86 per cent calculated from the uncorrected figures (550 to 77). The accumulation of immunes thus plays some part in the diminished kills recorded. It may be expected to play a larger part in the next epizootic, for in this area (as in many others) practically all the surviving rabbits have recovered from the disease.

Another immunological mechanism which may be of importance is the infection and active immunization of a proportion of kittens infected while they still possess antibodies derived from their immune mother. This is probably of major importance in the maintenance of mousepox in populations of laboratory mice, with only occasional fatalities[12]. Current experiments[13] indicate that kittens borne by myxoma-immune mothers retain detectable serum antibody and exhibit a modified response to infection for at least six weeks after birth. The number of recoveries occurring in laboratory experiments has

been small, but there has always been a considerable prolongation of the survival-time. Field observations made so far, and the common occurrence of the disease as explosive summer epizootics several months after the main breeding season, minimize the possible importance of this phenomenon, but it is of potential importance, especially if there were slight changes in the virulence of the virus or the genetic resistance of the host, or in areas in which active transmission occurred during the breeding season.

Genetic Changes in the Virus

Experiments with the fibroma–myxoma 'spectrum' of viruses[14] indicate that there are wide variations in the virulence of these viruses. Two variants of myxoma virus with lowered virulence have been isolated in the laboratory: Hurst's neuromyxoma[8] and Berry's 80*A* mutant[15]. Tests with the former variant have shown that it rarely causes death in laboratory rabbits infected with minimal doses, and that it is spread by mosquito biting only with considerable difficulty[16]. Mykytowycz[17] has recently recovered from a wild rabbit caught near Canberra a strain of myxoma virus which failed to kill any of the nine wild rabbits infected by contact. This strain, and other strains obtained in 1953 from several different localities in Australia, have allowed prolonged survival of laboratory rabbits infected with small doses of the virus, and an occasional recovery, and are undoubtedly slightly less virulent than the standard laboratory strain[13]. Several of these variants of slightly reduced virulence were recovered from mosquitoes captured in the area in which there was a 99·8 per cent case-mortality-rate in 1951–52, and a 92 per cent case-mortality-rate in 1952–53. It is likely that this reduction was due in part to the presence of this altered virus.

The future spread of such variants of reduced virulence is problematic. If, like neuromyxoma, they combine diminished virulence with a diminished capacity to multiply in epidermal cells, it is unlikely that they will spread readily enough to supplant the fully virulent virus. A variant which combined diminished killing capacity with the ability to attain high concentrations in the skin would be likely to spread.

Genetic Changes in Host Resistance

The Australian wild rabbit reacts differently from the laboratory rabbit to inoculation with the same dose of myxoma virus. The development of the disease appears to lag about one day behind what is found with laboratory rabbits. It is conceivable that there might be a fortuitous variation in innate resistance to myxomatosis in the wild rabbits in different areas of Australia, and this might account for different case-mortality-rates even on first exposure to the virus. It seems inevitable that the drastic selection imposed by myxomatosis will within a few years alter the genetic resistance of the Australian wild rabbit. In the absence of any knowledge of the heritability of innate resistance it is impossible to say how rapidly this process might occur, and whether it could within two or three generations cause detectable differences in the case-mortality-rates.

Environmental Factors

Two environmental factors are known which affect the mortality-rate in myxomatosis: the effects of continued high temperature[18], and concurrent infection with certain neurotropic viruses[19]. Continued day and night temperatures of 37° C. have not occurred under natural conditions; but the possibility that intermittent exposure to high environmental temperatures might permit the recovery of some infected animals has not yet been tested.

The Australian neurotropic virus (Murray Valley encephalitis virus) has been found to interfere with fibroma virus in a manner analogous to that described with Semliki Forest virus[20], and it is likely that a similar effect would occur with myxoma virus. However, the absence of MVE virus from southern Australia since 1951[21] precludes the possibility that this has been an important factor in the field.

Conclusion

Field observations supplemented by serum surveys have revealed that in some areas the case-mortality-rate in myxomatosis has been lower than that observed after the first impact of the disease in many parts of Australia. Survival through a second epizootic of some of the survivors of the first epizootic contributes to this result, but cannot account for it completely. During the past year variants of the virus of slightly diminished virulence have been isolated from natural cases of the disease and from mosquitoes captured in epizootic areas. The epidemiological significance of attenuated variants depends upon their ability to spread through the rabbit population; but their recovery from several samples of mosquitoes caught during epizootics in the Murray Valley suggests that in certain areas they may have replaced the original 'standard laboratory strain' with a consequent slight reduction in the case-mortality-rate. Genetic changes in the innate resistance of the rabbit population may have occurred but have not yet been demonstrated experimentally. It is not yet possible to forecast the long-term significance of these observations. Falling case-mortality-rates in greatly reduced rabbit populations will certainly occur, due to the accumulation of immune animals. Genetic alterations in either or both the virulence of the virus and the innate resistance of the host may be expected to occur, and may, in a sporadic manner, further reduce the case-mortality-rate. In spite of these changes, however, myxomatosis may permanently reduce the rabbit population in Australia, so that it attains a balance at a very greatly reduced population density.

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NEWS and VIEWS

Plant Biophysics at Leeds: Prof. R. D. Preston

Dr. R. D. Preston, whose appointment to the newly created chair of plant biophysics in the Botany Department at the University of Leeds has recently been announced, is one of the few scientists with an initial training in pure physics to make a career in botany. He graduated with first-class honours in physics at Leeds in 1929 but immediately began research, by invitation of the late Prof. J. H. Priestley and later in collaboration with Prof. W. T. Astbury, on fundamental botanical problems, notably those of cell wall molecular architecture and sap ascent. He spent the first seven years after graduation in association with the Botany Department as a holder of various postgraduate research awards, which included a Senior D.S.I.R. Studentship, an 1851 Exhibition Fellowship and, in 1935–36, a Rockefeller Foundation Fellowship which took him to Cornell University and gave him the opportunity of spending a year in strictly botanical work under Sharp, Eames and Curtis. On his return from the United States, Preston joined the teaching staff of the Botany Department, giving lectures in all aspects of plant physiology and in a number of general courses including plant morphology and elementary courses. He was promoted successively from lecturer to senior lecturer and eventually to reader.

Preston's readership coincided with the establishment of the Sub-department of Plant Biophysics by means of a substantial grant from the Department of Scientific and Industrial Research for basic equipment, including an electron microscope, in 1948. Plant biophysics as a normal teaching subject for undergraduates in botany had been introduced the year before. Preston's research output includes numerous papers on cell wall structure and sap ascent together with several more general articles in publications such as *Science News*, *Fibre Science*, the "Symposium on Deformation and Flow in Biological Systems", "Advances in Biophysics", etc. His own work has recently been summarized in his book "Molecular Architecture of Plant Cell Walls" (1952). He has lectured on biophysical subjects in the United States, Holland, Sweden, France and Italy, and in the more strictly biological field he has acted for many years as external examiner in biology for the Yorkshire teachers' training colleges. His promotion now to a chair in his own University is a fitting tribute to an outstanding achievement and a good augury for the maintenance of the fine traditions of the Leeds Botany Department.

Committee on Air Pollution

In reply to questions in the House of Commons on July 21, Mr. A. E. Marples, Parliamentary Secretary to the Ministry of Housing and Local Government, announced that the Minister, with the Secretary of State for Scotland and the Minister of Fuel and Power, has appointed a committee "To examine the nature, causes and effects of air pollution, and the efficacy of present preventive measures; to consider what further preventive measures are practicable; and to make recommendations". The committee will be assisted in its work by assessors from the Ministry of Housing and Local Government, Ministry of Fuel and Power, Ministry of Health, Department of Scientific and Industrial Research, Department of Health for Scotland, and Welsh Board of Health, and will begin work forthwith. The members of the committee are: Sir Hugh Beaver (*chairman*); Miss A. D. Boyd, housing manager, Rotherham County Borough Council; Dr. J. L. Burn, medical officer of health, Salford County Borough Council; S. R. Dennison, Fellow of Gonville and Caius College, Cambridge; Sir Roger Duncalfe, chairman of British Glues and Chemicals, Ltd., chairman of the Federation of British Industries Technical Legislation Committee and vice-president of the Federation of British Industries; Prof. T. Ferguson, professor of public health and social medicine, University of Glasgow; Dr. G. E. Foxwell, president of the Institute of Fuel; Dr. R. Lessing; G. Nonhebel, Imperial Chemical Industries, Ltd.; C. J. Regan, chemist-in-chief, London County Council; and Prof. O. G. Sutton, chairman, Atmospheric Pollution Research Committee.

University College, Ibadan: Report of the Visitors

The report of the Visitors to University College, Ibadan (pp. 42; from the College), covers a visit made during December 30, 1951–January 12, 1952, but also comments briefly on some subsequent developments. The Visitors (C. R. Morris, J. E. Harris and W. Adams) were impressed with the excellent start that the College has made. Although it does not enjoy full public confidence, the success of the College is of vital importance to Nigeria, and Ibadan is the necessary first step towards a Nigerian university. Of the three major problems facing the College at the time of the visit, those of the future policy for the Medical School and of finance are well on their way to solution through subsequent developments; that of academic self-government remains. The immediate tasks before the College, as seen by the Visitors, are first to strengthen its unity and to resist tendencies to fragmentation. Here the Academic Board can play a decisive part by taking up its full responsibilities and providing a strong unifying influence. The second task, to consolidate the gains made during the first four years of rapid growth, is one for the administrative as well as for the academic staff, and the student body. The third is to work out a long-term guiding plan of academic development and priorities, understood and agreed by the whole College, so that each new commitment it undertakes can be seen and judged against the background of a considered and balanced scheme of development. The Visitors point out that both the College and its staff are young and vigorous and that it has much to gain by retaining its youthfulness by giving every opportunity to the junior staff to play a full part in the work of the College and, in its staff recruitment, by continuing to attract young men and women to senior as well as junior positions. The fourth task is to establish the reputation of the College so that it enjoys the full confidence of responsible Nigerian opinion, and has a public standing and national support worthy of its position as the first university institution in Nigeria. The College is financially most vulnerable in its recurrent income; but a substantial increase in its endowment income has since been provided in a sum of £1·5 million voted as expendable endowment by the Government of Nigeria.

Wattle Research Institute, University of Natal: Report for 1951–52

The report of the Wattle Research Institute, University of Natal, for 1951–52 (pp. 76. Pietermaritzburg: University of Natal, 1952) is more than

the usual annual one, as it is now issued in August instead of January to coincide with the financial year of the Wattle Growers Union. The change, says the report, has enabled work in progress to be reported up to a well-defined seasonal phase and has allowed the writing-up to be done at a time of the year when the demands of field work are less insistent—points which will be understood by all field practical research workers. Considerable work has been carried out on the buildings of the Institute and the lay-out of the farm, with a planned road system which will comprise some twenty-two miles when completed. Some eighty acres of the farm have now been planted for experiments. Improvements have been made to the nursery, and a small plantation of black wattle has been established to facilitate *ad hoc* tests of the effect of insecticides, weed-control chemicals, and so forth. Part 1 of the report deals with administration, and Part 2 with research, including sylviculture, genetics and plant breeding, chemistry and entomology. Progress reports include one by H. Shaw, the director of the Institute, entitled "Natal, Home of the Union Wattle Industry". Filling of research-staff posts has proved somewhat difficult, especially the junior posts, in which there is a high wastage of junior assistants owing to resignations after a short period of service. Improved conditions of service are now being introduced.

Carnegie Trust for the Universities of Scotland : Annual Report for 1951–52

The fifty-first annual report of the Carnegie Trust for the Universities of Scotland (pp. 80 ; Carnegie Trust, Edinburgh, 1953) covers the academic year 1951–52 and includes the following items : the abstract of accounts ; a summary of grants for the period October 1, 1952–September 30, 1957 ; a report upon the work of investigators under the research scheme during the year ; a list of publications by fellows, scholars and recipients of grants since September 30, 1951 ; a list of awards for the year 1952–53 ; and details of assistance to students. Of the £37,365 distributed on research schemes during the year, £19,395 went to fellowships and scholarships ; £4,000 in block grants to the four universities, for use at their discretion in assisting professors, readers, lecturers and assistants on research projects during vacations ; £2,645 to the new scheme by which not more than ten specially selected members of the university staffs were given opportunity for travel and maintenance abroad on research ; and £8,160 for grants in aid of research. £3,165 was set aside to give partial guarantee against loss on publication of works of high merit. Reverting to the pre-war practice of utilizing for current income the annual interest from the general reserve fund and the fund founded from repayments by former beneficiaries (which increased during 1951–52 to £1,985 from thirty-six former beneficiaries), the executive committee from an annual income of approaching £127,000 offered to the Universities of St. Andrews and Aberdeen £50,000 in all, spread over the next quinquennium, 1952–57, subject to approval of the proposed use by the committee. £80,000 each was similarly offered to the Universities of Glasgow and Edinburgh, with £23,000 during the period to the extra-mural colleges. In regard to applications for fellowships and scholarships, the executive committee points out that a number of applications received should more properly have gone to the Department of Scientific and Industrial Research. The scheme for the endowment of postgraduate study and research is appended to the report, and the committee directs attention to the second paragraph of the scheme which indicates that where science scholarships are concerned, more especially in physics and chemistry, the committee reserves the right to give preferential treatment to applicants ineligible to receive allowances from the Department of Scientific and Industrial Research.

Journal of Histochemistry and Cytochemistry

Two numbers of the new *Journal of Histochemistry and Cytochemistry* have now appeared. The new journal is edited by R. D. Lillie for the American Histochemical Society and is published by Williams and Wilkins (£3 a year, post-paid). There will at present be six numbers a year, giving an aggregate of about 500 pages per volume. Manuscripts, books for review and all inquiries concerning material should be addressed to Dr. R. D. Lillie, National Institutes of Health, Bethesda 14, Maryland, U.S.A. At present, papers on histochemistry and cytochemistry are widely scattered through the literature. No doubt this will continue to be the case ; but workers in these fields will welcome a journal which is primarily devoted to cytochemistry, particularly if the new journal concentrates on methods. Papers which are primarily studies of biological problems, and which incidentally make use of histochemical and cytochemical methods, will more properly find their places in older journals. But there is a great field of investigation of cytochemical methods, much of which is highly controversial : studies in this field will find a more appropriate home in the new journal. Each number of the new journal will also include a list of current papers on histochemistry published in other journals.

Royal Scottish Museum, Edinburgh : Report for 1952

The annual report of the Royal Scottish Museum for 1952, while recording the normal activities of display and the systematic arrangement of reserve material, emphasizes the important part played by the staff in various educational and cultural organizations. To mention only a few examples, the director, Dr. D. A. Allan, is one of the two British members of the executive of the International Council of Museums and acts as assessor and consultant in connexion with the award of Carnegie grants to Scottish Museums ; Mr. Cyril Aldred is honorary secretary of the Scottish Federation of Museums and Art Galleries ; and Dr. A. C. Stephen acts as examiner for the diploma of the Museums Association. The sum total of the activities of the staff in local, national and international organizations forms an impressive record.

United States National Museum

The annual reports of the United States National Museum for 1951 and 1952 well illustrate the balance it is always necessary to keep in a well-planned museum between direct and indirect service to the public. Direct service is through exhibits, talks to visiting groups, answering of inquiries ; while the indirect service to the community is through the cataloguing, indexing and research on the collections. From the point of view of the staff of a museum, it may be said that the effective performance of both these functions depends on that essential element in the work of a successful museum, namely, research.

Realizing this, the United States National Museum at Washington concentrates on research, and its annual reports form an impressive record of the work of the staff in this important direction. The scope of these investigations is so large that it is perhaps invidious to particularize; but mention might be made of the excavation of a large Cheyenne village in South Dakota where the evidence helped to interpret the role of Indian tribes before and during the early historic colonization. Reports have also been prepared on mammals recently collected in northern Australia, in arctic America and in the eastern United States, and also on the evolution of the specialized breeding habits of the honey guides, an African family of birds. Full geological details of the birth and growth of a volcano are given in a report on the Volcán de Paricutin in Mexico.

Directory of Scientific and Technical Libraries South of the Sahara

THE Scientific Council for Africa South of the Sahara has issued as Publication No. 3 a "Directory of Scientific and Technical Libraries in Africa South of the Sahara" (pp. 61; P.O. Box 21, Kikuyu, Kenya, 1953; 2*s*. 6*d*.). This represents the first stage of work projected by the Council on scientific and technical library services in Africa. Both general and special libraries are included, and entries are arranged first alphabetically under the headings of metropolitan countries participating in the work of the Council, then regional groupings of territories, where applicable, and finally under separate territories. Under each regional or territorial heading the libraries or departments concerned are listed and numbered in alphabetical order, and the geographical and subject indexes refer to country and number. Although the bulk of the entries relate to government, university or institutional libraries, a few industrial libraries—for example, those of African Explosives and Chemical Industries, Ltd.—are included. The principal subjects covered, the number of volumes, pamphlets and current periodicals are indicated for each library. It is intended to follow the Directory with lists of periodical literature held by these libraries, where not already available, and, finally, to compile detailed catalogues for all the larger libraries.

Forest Research in India and Burma, 1948–49

PART 2 of "Forest Research in India, 1948–49" deals with reports for Burman and Indian Provinces (pp. 72. Delhi: Manager of Publications, 1952; Rs. 5 or 8*s*.) and is divided into four chapters as follows: sylviculture and working plans are dealt with for Assam, West Bengal, Bihar, Orissa, Bombay, Central Provinces and Berar, Burma, Coorg, Madras, Punjab and United Provinces; forest botany for Assam, West Bengal, Central Provinces and Berar, and Burma; forest entomology for Assam, Central Provinces and Berar, Burma and Punjab; utilization and economic research for Assam, West Bengal, Orissa, Bombay, Burma, Madras and United Provinces. An outstanding and serious problem faces Burma in the important branch of forest working plans. Up to the outbreak of the Second World War, Burma held her forests in high esteem and had working plans covering the greater part of the country, thus safeguarding the forests from over-exploitation. Many of these plans had been revised several times. It is impossible to attribute the present deplorable position entirely to the destruction of records during the War, although this claim is made. The real reason is that given: "Most divisional forest officers are new to the divisions and have no previous knowledge of their charges and are therefore not quite capable to cope with the revision of the plans until they know more about the division. The assistants are few and inexperienced to give much help in the compilation of the plans and most officers have new and inexperienced clerical staff".

A *Stauropteris* with two Megaspores

A LOWER CARBONIFEROUS species of *Stauropteris*, *S. burntislandica*, is described as normally bearing two well-developed megaspores—a condition unknown elsewhere in the plant kingdom (K. R. Surange, *Phil. Trans. Roy. Soc.*, B, **237**, No. 642, 73; 1952). The sporangium containing small spores which was already known is now recognized as being a microsporangium. The author considers that heterospory may be found in other species of this genus. The reconstruction of the frond, essentially a repeatedly dichotomizing branch system, suggests that it may have been supported on an underground stem. Critical specimens showing the attachment of the *Bensonites* fruits to small ultimate *Stauropteris* branchlets have been obtained. These spindle-shaped bodies, formerly recorded as *Bensonites*, are now known to be megasporangia, typically containing two well-developed megaspores. There are indications that a tetrad of young megaspores was initially present but that two of them had degenerated. The mode of spore liberation is still obscure. The author considers that *Stauropteris* can no longer be included among the primitive ferns: it deserves to be placed in a separate order of its own. Phylogenetically, it may have sprung from the common ancestor of the Psilophytales, together with the Zygopterideæ, but may have separated early from that group and evolved in the direction of the Pteridospermæ.

Experimental Taxonomy

IN a survey of "Methods of the Experimental Ground in Relation to Taxonomy", Dr. W. B. Turrill (*Kew Bull.*, **3**, 427; 1952) has considered the aims and procedures in experimental taxonomy. These are held to be essentially supplementary to the herbarium and other methods used by the taxonomist, and not a replacement of them. The advantages and limitations of the experimental approach, and the methods and principles to be adopted in it, are set out. Ecological and genetical studies, undertaken in the taxonomic interest, are naturally among the main features of this work. Though experimental taxonomy is unavoidably of a long-range character, it offers a wide and interesting field for discovery and introduces students to a new and dynamic aspect of taxonomy.

Earthquakes in New Zealand during 1951

SOME 291 earthquake epicentres for earthquakes which happened in New Zealand during 1951 have been catalogued by R. C. Hayes and recently published (*N.Z. J. Sci. Tech.*, B, **34**, No. 4; 1953). The general distribution followed a familiar pattern. Most of the earthquakes had epicentres in the South Island north of latitude 43° S., in the straits between the Islands and in North Island except the portion north of latitude 38° S. and west of longitude 176° E., where none occurred. The only epicentres south of latitude 43° S. were three immediately to the west of Dunedin, two near lat. 45° S., long. 169° E., and

one at sea near lat. 44° S., long. 167·3° E. Eight shocks during the year were felt with intensity 6 or greater on the Modified Mercalli Scale, and nine shocks attained an instrumental magnitude of 6 or greater. Only three of these earthquakes had intensity and magnitude both greater than 6, these being as follows: February 10d. 03h. 27·9m., G.M.T., lat. 40·2° S., long. 177·0° E., instr. mag. 6·25–6·5, Mod. Merc. intensity 6; April 23d. 06h. 50·3m. G.M.T., lat. 37·8° S., long. 178·2° E., instr. mag. 6·75, Mod. Merc. intensity 7 (?); June 24d. 04h. 41·8m., G.M.T., lat. 39·4° S., long. 176·2° E., instr. mag. 6·25, Mod. Merc. intensity 6–7. Isoseismal lines are drawn for "two of the most important earthquakes of the year". One of these was that of June 24, mentioned above, and the other occurred on January 10d. 19h. 15m., G.M.T., lat. 42·8° S., long. 173·2° E., instr. mag. 5·6 *ca.*, Mod. Merc. intensity 7. The January earthquake was felt in Christchurch with Modified Mercalli intensity 4, and the June earthquake was felt in Wellington with Modified Mercalli intensity 3.

Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: J. H. Gisborne (botanist, Agricultural Department, Nigeria), principal agricultural officer, Nigeria; F. J. Harper (senior agricultural officer, Nigeria), deputy director of agriculture, Sarawak; C. A. Thorold (plant pathologist, Nigeria), principal research officer, Nigeria; J. M. Watson (senior agricultural officer, Uganda), director of agriculture and veterinary services, Somaliland Protectorate; J. M. S. Usher-Wilson (senior agricultural officer, Nigeria), principal agricultural officer, Nigeria; W. B. Collins, J. Gordon, M. T. Horwood, D. A. Lane and J. M. Ramsay (assistant conservators of forests, Gold Coast), senior assistant conservators of forests, Gold Coast; R. M. Harley and C. J. Taylor (senior assistant conservators of forests, Gold Coast), conservators of forests, Gold Coast; D. W. Powell (geologist, Water Development Department, Tanganyika), geologist, Uganda; R. G. Seal (geologist, British Guiana), geologist, Uganda; E. W. Temple-Boreham (game ranger, Kenya), senior game ranger, Kenya; P. O. M. Hosten (land settlement supervisor, Trinidad), agricultural officer (land settlement), Trinidad; T. A. M. Nash (chief entomologist, West Africa Inter-Territorial Research), deputy director, West Africa Inter-Territorial Research; F. W. Will (livestock officer, Nyasaland), livestock marketing officer, Veterinary Department, Nyasaland; W. D. Ware-Austin, agricultural officer, Kenya; I. MacI. Macfarlane, veterinary officer, Nigeria; H. C. Hodgson, pyrethrum chemist, Kenya; Dr. P. J. Mullaney, chemical pathologist, Barbados; J. Tarala, veterinary officer, Kenya.

University of London

The following announcements have recently been made from the University of London. The titles of professor emeritus in the University have been conferred on the following on their retirement from their respective chairs: Prof. W. G. Bickley, mathematics at the Imperial College of Science and Technology; Prof. William Brown, plant pathology at the Imperial College of Science and Technology; Prof. J. W. Munro, zoology and applied entomology at the Imperial College of Science and Technology; Prof. H. R. Robinson, physics at Queen Mary College; and Prof. Gilbert Stead, physics at Guy's Hospital Medical School. The following have been appointed to University readerships, all tenable at the Imperial College of Science and Technology, in the subjects as indicated: J. R. Ashby (civil engineering), Dr. C. C. Butler (physics) and Dr. R. M. Goody (meteorology). The title of reader in mathematics in the University has been conferred on Dr. D. B. Scott, in respect of the post held by him at King's College.

The Oldest Agricultural Research Institute

Dr. W. Lane-Petter points out that the description of Rothamsted in the leading article in *Nature* of July 18 as "the oldest agricultural research institute in the world" might be misunderstood, as Boussingault set up an experimental farm at Bechelbronn in 1836, seven years before Rothamsted was founded. Boussingault's farm, however, was abandoned after the Franco–German War in 1870, and Rothamsted can thus now claim to be the oldest agricultural research institute.

Announcements

The British Standards Institution is moving from its present premises, and, as from August 17, its new address will be No. 2 Park Street, London, W.1 (Telephone, MAYfair 9000).

The Bibliography of Scientific Publications of South Asia, No. 7, covering India, Burma and Ceylon, for January–June 1952 (pp. 171. New Delhi: Unesco South Asia Science Co-operation Office, 1953; n.p.) includes a supplementary catalogue of scientific publications in South Asia and a supplementary list of new periodicals. The arrangement of the entries is the same as in previous issues of the bibliography, and the present issue includes some 3,500 entries.

The Year Book for 1953 of the Library Association (pp. 528. London: Library Association, 1953. 21*s.*, or 15*s.* to members) is the usual convenient reference work including, besides the charter and by-laws of the Association, lists of officers and committees, members and professional register and the syllabus of examination, and a list of library associations of the world. There are also lists of publications of the Association, a list of jubilees and centenaries and a graded list of text-books and works of reference, now running to sixty-seven pages.

A List of Publications of the Commonwealth Scientific and Industrial Research Organization, Australia, to December 1952, issued by the Commonwealth Council for Scientific and Industrial Research (pp. 32; Melbourne, 1953), lists serially the handbooks and monographs, journals, bulletins, pamphlets, circulars, divisional publications, etc., of the Council and its predecessors, of the Institute of Science and Industry and of the Advisory Council of Science and Industry. Those out of print are indicated, and, unless otherwise mentioned, copies of the publications listed are obtainable from the Secretary (General Administration), Commonwealth Scientific and Industrial Research Organization, 314 Albert Street, East Melbourne, C.2, Victoria, Australia.

Erratum. In the communication by Mr. B. Lincoln on "Elastic Deformation and the Laws of Friction", published in *Nature* of July 25, p. 169, the sentence beginning at the sixth line of the second paragraph should read: "The assumption that $n > 0{\cdot}67$ indicates some degree of plastic deformation may, however, be unjustified, . . .".

ADAPTATION IN MICRO-ORGANISMS

A SYMPOSIUM on "Adaptation in Micro-organisms" was held by the Society for General Microbiology during April 14–15 at the Royal Institution, London. The papers of the contributors had been circulated to members of the Society beforehand, and the symposium was arranged in the form of discussions of each paper following a brief introduction by the author.

Dr. R. Y. Stanier (University of California), who introduced the symposium, defined two types of adaptive phenomena. Evolutionary adaptation involves selection of an organism possessing suitable characteristics which enable it to multiply in a specific environment and to survive natural environmental changes. In physiological adaptation, cells of a population adjust themselves directly to meet a sudden change in the environment. Classical genetical adaptation of micro-organisms is restricted, he suggested, by the predominance of haplophase and "a spotty distribution of sexuality", although this latter characteristic was questioned in discussion by Dr. Muriel Robertson and Dr. G. Pontecorvo. Yet micro-organisms live in micro-environments which are subject to rapid fluctuations—the environments are "discontinuous in time". We might expect, therefore, physiological adaptation to be of considerable importance among microbial populations.

Dr. A. C. R. Dean and Sir Cyril Hinshelwood (University of Oxford) discussed further the distinction between adaptations which could be attributed to mutant selection and those which are based upon changes in the whole population. They have evidence that the ability of *Bacterium lactis aerogenes* (*Aerobacter aerogenes*) to grow in the presence of proflavine or chloramphenicol is not due to selection of drug-resistant strains. For example, cultures derived from colonies which have grown in the presence of high concentrations of proflavine show no greater resistance to proflavine than does the original culture which has never come in contact with the drug. Resistance has not been deeply impressed on the organism, neither has a mutant been selected. However, resistance which is not lost on growth in the absence of the drug may be impressed by continuous sub-culture in the presence of the drug. That this observation could be due to mutant selection seemed to Dr. Dean and Sir Cyril to be incompatible with the high reversion-rate which has to be assumed to account for the stability of the non-resistant culture. They concluded that the selection of mutant strains might not play a big part in the development of drug resistance.

Dr. A. W. Ravin (Columbia University, New York) discussed the occurrence in populations of *Aerobacter aerogenes* of cells with varying ability to utilize citrate and other intermediates of the tricarboxylic acid cycle. Normally, growth of the organism on these compounds occurs after a lag during which nearly all the population develop the ability to utilize these acids. This ability is lost on subculture on glucose, but is regained on further subculture on citrate. In any culture of the organism, however, Dr. Ravin has shown that there are some mutant cells which do not utilize citrate; their relative number is increased by irradiation with ultra-violet light. Cultures derived from such cells show a permanent loss of ability to utilize citrate. It was pointed out that heterogeneous populations probably occur very frequently in microbiology and may complicate studies of adaptation. In discussion Dr. Monod suggested that such heterogeneity of a population might be due to some cells having, and others lacking, energy reserves or intermediates of some kind necessary for synthesis of the adaptive enzyme required for growth. Later in the symposium, Dr. M. R. Pollock followed up this point of an overall shortage of some such compound, speaking of the "quantum mechanics of bacteria".

Dr. Ravin also introduced the paper of Dr. P. P. Slonimski (Laboratoire de Génétique du Centre National de la Recherche Scientifique, Paris), who was unable to be present. Dr. Slonimski's work on the effect of acriflavine on the formation of cytochrome oxidase by yeast provides an interesting example of a specific relation between the hereditary and non-hereditary nature of formation of an enzyme system. Yeast cells which have been grown in the presence of acriflavine give rise to small colonies. Cells derived from such colonies are deficient in cytochrome oxidase and retain this characteristic indefinitely during vegetative reproduction. Acriflavine also specifically inhibits the adaptive formation of cytochrome oxidase and related enzymes in anaerobically grown yeast when the cells are exposed to oxygen. The experimental results indicate that acriflavine inhibits some specific reaction which governs both the hereditary and the adaptive mechanisms of respiratory enzyme formation.

Other papers on the first day dealt with the mechanism of synthesis of adaptive enzymes. The biosynthesis of adaptive, as opposed to constitutive, enzymes can be studied directly, and it seems reasonable to believe that information derived from such studies should be applicable to the formation of constitutive enzymes and of proteins in general.

Dr. M. R. Pollock (Institut Pasteur, Paris, and National Institute for Medical Research, London) spoke of the difficulty of studying adaptive enzyme synthesis as an isolated phenomenon, since it requires such close integration of energy-yielding reactions and reactions yielding intermediates in the synthetic chain. The adaptive formation of penicillinase by *Bacillus cereus* has been investigated in cells during the logarithmic phase of growth when metabolism has reached a steady state. Brief exposure of the cells to penicillin at this stage induces formation of the enzyme, which continues after removal of the drug. Quantitative considerations indicate that the ratio of molecules of penicillin fixed to molecules of penicillinase formed is very small, suggesting a catalytic role for penicillin, probably as a complex with a cell component. Dr. Pollock visualized a cyclical chain of reactions primed by an inducer-cell component complex and leading to the formation of the enzyme.

The role of the inducer in enzyme synthesis was further discussed by Dr. M. Cohn and Dr. J. Monod (Institut Pasteur, Paris). They suggested that induction is necessary in the formation of both constitutive and adaptive enzymes. In the former case the specific inducer may be a product of the metabolism of normal cells, whereas an external inducer is required for the creation of an adaptive system. It is postulated that either external or internal inducers

give rise to organizers which are concerned in the arrangement of amino-acids into enzyme proteins. Thiophenol-β-galactoside is apparently a competitive antagonist of induced β-galactosidase synthesis in *Bacterium coli*, and studies have been commenced in an effort to find compounds which may act as specific antagonists of inducers of constitutive enzymes.

Dr. S. Spiegelman and Dr. H. O. Halvorson (University of Illinois) have investigated the utilization of free amino-acids in cells of *Saccharomyces cerevisiæ* during the formation of the adaptive system maltozymase. Enzyme synthesis occurs at the expense of the free amino-acids within the cells and cannot occur if the cells contain no free amino-acids. Their results suggest that the first stable (an important qualification which was sometimes overlooked in discussion) intermediates in enzyme formation must be of considerable complexity.

Prof. R. Knox (Guy's Hospital Medical School, London) emphasized differential temperature sensitivity as a means of distinguishing between adaptive processes and growth not involving such mechanisms. The formation of adaptive enzymes appears to be more sensitive to temperature change than is cell proliferation. For example, the sensitivity of *Bacillus cereus* to penicillin is increased at temperatures which suppress the adaptive formation of penicillinase, but which do not affect growth in the absence of the drug. The sensitivity of adaptive changes to heat may be of importance in chemotherapy; there is already some evidence that isoniazide is more effective against tubercular infection in animals with abnormally high body temperatures.

On the second day Dr. E. P. Abraham (University of Oxford) ably introduced a discussion on drug resistance among micro-organisms. The development of resistance has most frequently been observed in cultures which have been in contact with the drug. In some cases selection of a spontaneous mutant may occur; in others, growth in the presence of the drug seems to be due to adaptive changes in most of the cells of the population. Dr. Abraham considered it very difficult to determine which type of change has occurred and found the replica technique of Lederberg and Lederberg alone convincing in its ability to make this distinction. Finally, he pointed out that it is scarcely surprising that so little is known about the factors causing drug resistance, when the modes of action of so few drugs have been elucidated.

It was evident from the following discussions that organisms differ greatly in their ability to tolerate any one drug, and that even in a single strain different types of resistant variant may be isolated in a single experiment.

This was particularly emphasized by Dr. Mary Barber (St. Thomas's Hospital Medical School, London), who showed slides illustrating the wide variation, both heritable and non-heritable, among strains of *Staphylococcus aureus* which can grow in the presence of antibiotics.

Dr. D. A. Mitchison (Postgraduate Medical School, London) discussed the variations in resistance found among organisms isolated from hosts after streptomycin and isoniazid therapy. Changes in the population of tubercle bacilli have been noted in cases treated with streptomycin; drug-resistant strains may be replaced by sensitive strains on withdrawal of the drug. He stressed the importance of this phenomenon and also the relation of resistance to virulence and viability in medicine and public health.

The concluding papers dealt with a variety of micro-organisms ranging in size from bacteriophage to *Paramecia*. Dr. L. F. Hewitt (Serum Research Institute, Surrey) discussed the control that bacteriophages may exert over evolution in bacteria. They are known to act first by selection of phage-resistant strains due to lysis of phage-sensitive cells, and, secondly, by the actual transmission of genetic characters of one cell to another through an infecting phage entering a cell without lysis occurring. In the second case detection is difficult since it depends upon contact of the phages with organisms sensitive to lysis by them. In addition, bacteriophages are themselves capable of adaptation. Thus from one phage active against a particular strain of *Corynebacterium diphtheriæ*, phages can be obtained which lyse cells of different serological type.

Many of the arguments concerning the nature of changes in bacterial populations have centred on the question of whether or not a mutation has occurred. Dr. G. H. Beale (University of Edinburgh) pointed out that it is impossible to provide unequivocal answers to such questions since controlled breeding experiments cannot be carried out with bacteria. In *Paramecium*, however, such experiments can be performed. He discussed several types of adaptation in this organism, all of which arose during asexual reproduction. In the case of variation in antigenic structure, it was shown that a change in the cytoplasm had occurred rather than a gene mutation followed by selection. Similar phenomena probably account for other adaptations studied in this organism. Nevertheless, the ability of a strain to adapt to given conditions is genetically controlled.

Dr. L. F. L. Clegg (National Institute for Research in Dairying, Shinfield) and Dr. S. E. Jacobs (Imperial College of Science and Technology, London) described work with thermophilic organisms which grow optimally at temperatures above 50° C. Though most thermophiles can adapt themselves to grow at lower temperatures, there are very few examples of adaptation of a mesophilic organism to the thermophilic mode of life. Dr. M. R. Pollock suggested that the inability of some thermophiles to grow at lower temperatures might reside in changes in the equilibrium of reactions concerned in synthetic processe in the cell.

Prof. W. Brown and Dr. R. K. S. Wood (Imperial College of Science and Technology, London) dealt in particular with the adaptation of fungi to their natural habitat. Little is known of the physiological processes which enable them to flourish in the chosen conditions. The life-cycle of fungi is a very important factor in their ability to survive wide environmental fluctuations. The vegetative stage gives rise quickly to conidia, which can germinate immediately when favourable conditions arise. Under unfavourable conditions, fungi can carry on sexual reproduction which yields long-lived resistant spores.

Perhaps the most striking impression gained from the symposium as a whole was the very considerable measure of agreement over the respective parts played by single cell and selective adaptation in microbial growth. Much of the lively discussion appeared to arise through the inability of chemists, bacteriologists and geneticists to appreciate fully one another's modes of expressing their conclusions. It was also clear that even a surface understanding of the closer physiological relationship between the two mechanisms of adaptation must await further experimental work.

SMITHSONIAN INSTITUTION

ANNUAL REPORT FOR 1951–52

THE report of the Smithsonian Institution for the year ended June 30, 1952*, includes the secretary's report, to which are appended departmental reports on, *inter alia*, the United States National Museum, the Bureau of American Ethnology, the International Exchange Service, the Astrophysical Observatory, the National Zoological Park, the National Air Museum, the Canal Zone Biological Area and the Institution's library, and the report of the executive committee of the Board of Regents. The secretary's report is the last from Dr. Alexander Wetmore, who retired from administrative duties at his own request, to continue scientific work as research associate of the Institution, and was succeeded at the beginning of this year by Dr. L. Carmichael (see *Nature*, 169, 952; 1952).

In his final report, Dr. Wetmore points out that, although the pay-roll of the Institution has more than doubled during the past twenty years, the hours of service per week have decreased (from 20,592 man-hours in 1942 to 20,200 hours in 1952, with a greatly increased work load). Unless this situation is speedily remedied, the Institution will have to curtail its duties or its services. All available space is now fully utilized; but additional buildings for the United States National Museum and National Air Museum, for the collections in art, and for research work in natural history and other fields are essential, and a substantial increase in endowments is required for this purpose as well as for research and publications and general maintenance. Of the present appropriation of 2·5 million dollars, nearly 900,000 dollars goes on maintenance and operation of buildings, nearly 800,000 dollars on the National Museum, 319,000 dollars on general services, 177,000 dollars on the National Air Museum and 116,000 dollars on the Astrophysical Observatory. During the year the Mary Vaux Walcott Fund for Publications in Botany, amounting to 60,000 dollars, was established: publications issued under this Fund will be chiefly technical and will relate to researches of the United States National Herbarium.

More than 607,000 specimens were received and distributed among the six departments of the United States National Museum, which also issued twenty-seven publications during the year. Field-work was conducted on the distribution and variation of the bird-life of the Republic of Panama, on the ecology and on the life-history of freshwater fishes in the streams draining the mountain and Piedmont plateau sections of the Atlantic slope from Virginia to Georgia and Alabama. The ornithological survey of Columbia was continued and also the study of mammalian and other hosts involved in the transmission of scrub typhus in the vicinity of Mount Kinabalu, British North Borneo, while a field study was made of the relation of the Bromeliaceæ to malarial control in eastern Brazil.

The bulk of the report on the Bureau of American Ethnology is occupied by a report on the River Basin Surveys, prepared by Dr. F. H. H. Roberts, director of the Surveys. Since the beginning of this project seven years ago, 3,105 archæological sites have been located and recorded, and, of these, 578 have been recommended by excavation or limited testing. The excavation work during the year covered thirteen reservoir areas in eleven States, with twenty-two excavating parties in the field. Besides this, the Bureau's staff continued systematic research on Mexican and Panamanian archæology, on the Eskimo and archæology of Cornwallis Island in the Canadian Arctic, on the Maya language, on the Iroquois and on Meso-American archæology. During the year the activities of the Institute of Social Anthropology were integrated with those of the Institute of Inter-American Affairs under an arrangement by which the Smithsonian anthropologists will be available for programme analyses of technical aid projects.

The number of packages of government, scientific and literary publications handled during the year by the International Exchange Service totalled 1,001,614, weighing 825,627 lb., consignments being made to all countries except China and Rumania. In exchange for similar publications of other countries, sixty-two full and forty-two partial sets of United States official publications were sent abroad, as well as eighty-seven copies of the Federal Register and ninety-four of the Congressional Record. Lists of depositories are given in the report. Visitors to the National Zoological Park numbered about 3·3 millions, and the 2,675 animals included fourteen species not previously exhibited. A list of animals in the collection at June 30, 1952, is given.

At the Astrophysical Observatory solar-radiation studies continued at the high-altitude stations at Table Mountain, California, and at Montezuma, Chile, while five silver-disk pyroheliometers were constructed and furnished at cost to institutions in France, Finland, Central Africa, Greece and Rhode Island. The study at Table Mountain on the ozone content of the upper atmosphere from daily bolographic records continued, and, in the Division of Radiation and Organisms, studies on bean seedlings indicate that photomaturation responses are not directly concerned either with chlorophyll synthesis or photosynthesis, but are due to a regulatory mechanism associated with a pigment having maximum absorption in the far red. Clear evidence was also obtained that the synthesis of anthocyanin is a photochemical response, separate and distinct from photosynthesis. Work on the effect of growth regulators on the uptake of nutrient salts by bean seedlings continued, and it appears that the reduced uptake patterns are chiefly related to decreased growth of the plants treated with the growth regulator.

The principal purpose of the (Panama) Canal Zone Biological Area is to provide a safe tropical environment for research, and during the year 602 visitors went to the Barro Colorado Island station, of whom forty-eight were men of science who used the facilities of the island for biological studies. One such study, by Dr. E. Eisenmann, resulted during the year in the publication by the Institution of the "Annotated List of Birds of Barro Colorado Island, Panama Canal Zone", listing 306 species; and since the time when the list was given in the 1950 report, seven species of vertebrate animals other than birds have been added to the known fauna of the area, bringing the total of vertebrate forms to 486. During the year the National Museum Library was merged physically with the general library and all major library functions were consolidated and housed in the Natural History Building. The library received 60,512 publications

* Smithsonian Institution. Report of the Secretary and Financial Report of the Executive Committee of the Board of Regents for the Year ended June 30, 1952. (Publication 4102.) Pp. 175. (Washington, D.C.: Govt. Printing Office, 1953.)

during the year, mostly by gifts and exchanges. A list of Smithsonian publications during the year is appended, and these include, besides the sixth revised edition of the Smithsonian Meteorological Tables and the Smithsonian Logarithmic Tables, E. A. Goldman's "Biological Investigations in Mexico", A. H. and L. F. Clarke's "The Butterflies of Virginia" and F. Rasetti's "Middle Cambrian Stratigraphy and Faunas of the Canadian Rocky Mountains".

UNIVERSITY AFFAIRS IN GREAT BRITAIN, 1951–52

THE "Returns from Universities and University Colleges in receipt of Treasury Grant for the Academic Year 1951–52"*, issued by the University Grants Committee, show a further decline of 1,856 in the number of full-time students—to 83,458, compared with 85,314 in 1950–51 and 85,421 in 1949–50. In English universities, full-time men students decreased by 724, but women students increased by 128; for Wales the corresponding figures were 276 and 6, while for Scotland there were 861 fewer men and 129 fewer women. Overseas students from within the British Commonwealth increased by 264 to 3,921 full-time and 1,636 part-time students, and students from foreign countries by 137 to 3,039 full-time and 1,320 part-time students. While the reduction in numbers of full-time students was distributed fairly generally over all faculties, except dentistry, which increased by four, from 2,885 in 1950–51 to 2,889 in 1951–52, it will be noted that although the largest decrease (852) was in arts students (to 35,936), those in pure science decreased by 115 to 17,053, of technology by 376 to 10,215, of medicine by 291 to 13,910, of agriculture by 188 to 2,418, and of veterinary science by 38 to 1,037. Full-time advanced students of pure science decreased by 35 to 2,858, of medicine by 27 to 965, of agriculture by 4 to 274, and of veterinary science by 3 to 10. On the other hand, full-time advanced students of technology increased by 98 to 1,105, of dentistry by 20 to 42, and of arts by 17 to 3,314. Of the full-time students, 66,409 were reading for a first degree, 5,505 for a first diploma, and 11,544 were engaged in research or other advanced work, the corresponding figures for 1950–51 being 67,743, 5,244 and 11,327, respectively.

The proportion of assisted students was practically unchanged (72·4 per cent compared with 72·5 per cent in 1950–51); but although the figure for England as a whole remained unchanged, decreases at Oxford (from 75·7 to 71·7 per cent) and at Cambridge (from 74·3 to 67·8 per cent) were more than offset by increases at London (from 65·9 to 67·7 per cent) and at other universities (from 77·9 to 79·5 per cent). In Wales the percentage of assisted students increased from 85·9 to 88·3; but in Scotland there was a decrease from 63·1 to 61·6. The dependence on Parliamentary grants again increased, and now represents 66·5 per cent of recurrent income, compared with 64·9 per cent in 1950–51, only 14·8 per cent coming from fees, compared with 16·6 per cent in 1950–51, 5·2 per cent from endowments, 4·1 per cent from local authority grants and 1·9 per cent from donations and subscriptions, compared with 5·5 per cent, 4·3 per cent and 1·8 per cent, respectively, in 1950–51. The ratio of staff to students again increased, the full-time teaching staff being now 8,952 compared with 8,603 in 1950–51 and 7,930 in 1949–50. The increase was distributed fairly generally over most grades—professors, 43; readers, assistant professors and independent lecturers, 8; senior lecturers, 71; lecturers, 222—but assistant lecturers and demonstrators decreased by 58 to 1,537. Classified figures are included for the 2,454 full-time teaching staff of the University of London and for the staffs of its libraries, and the analysis of expenditure of the institutions of the University of London is now accompanied by those of the Universities of Durham and Wales.

Of the full-time students, 63,584 were in England, 4,863 in Wales and 15,011 in Scotland. Of these, 15,084 were at Oxford and Cambridge, 18,312 at London, and 30,188 at other English universities and colleges. Changes at the individual universities and colleges were usually slight, only Cambridge and North Staffordshire University College (157 to 300) showing increases of more than a hundred students, and only the universities of Oxford, Liverpool and Manchester and the Manchester College of Technology decreases of more than a hundred. The proportion of full-time students residing in colleges and halls of residence increased to 25·9 per cent; the proportion of men in residence was 21·2 per cent and of women 41·2 per cent, while 33,005 students (39·6 per cent) were in lodgings and 28,828 (34·5 per cent) at home. Of the 22,414 students admitted for the first time in 1951–52 (an increase of 191 on 1950–51), 20,567 were reading for a first degree and 1,847 for a first diploma, and of those reading for a first degree, 1,926 were less than eighteen years of age and 11,542 were nineteen or more. There was no significant change in the distribution of full-time students compared with 1949–50 or 1950–51. Arts students again represented 43·1 per cent of the total, those in pure science 20·4, in medicine 16·7, in technology 12·4, in dentistry 12·5, in agriculture 2·9, and in veterinary science 1·2 per cent. While the proportion of full-time advanced students of technology increased to 12·9 per cent compared with 11·8 per cent in 1950–51, there is no other sign in these returns of any response to the urgent call for more university-trained technologists, and although 25·8 per cent of full-time advanced students were working for a teacher's diploma, the contribution of the universities towards the supply of science teachers cannot be estimated from these returns. Of the full-time students, 36,745 out of 49,275 men, and 10,160 out of 14,309 women in England, were receiving assistance in the way of scholarships, exhibitions or other awards from public or private funds; for Wales, the corresponding figures are 3,154 out of 3,546 men, and 1,142 out of 1,317 women; and for Scotland, 7,275 out of 11,149 men, and 1,976 out of 3,862 women. Of 63,970 full-time men students, 36·8 per cent were in arts, 21·5 per cent in pure science, 17·2 per cent in medicine and 15·7 per cent in technology; for the 19,488 women students the corresponding figures are 63·3, 17·0, 15·1 and 0·9 per cent. Medicine and dentistry claimed 51·1 per cent of the part-time advanced students, arts 33·0, technology 8·0, and pure science 7·2 per cent, compared with 44·6, 30·4, 9·6 and 8·7 per cent, respectively, in 1950–51.

The recurrent income of the universities and university colleges of Great Britain increased by

* University Grants Committee. Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1951–1952. (Cmd. 8847.) Pp. 44. (London: H.M. Stationery Office, 1953.) 2s. 6d. net.

£1,479,876 to £25,747,999, of which £17,126,993 was from Parliamentary grants, £3,807,440 from fees, £1,347,570 from endowments and £1,044,151 from grants from local authorities. Of the total income from public funds of £18,171,144 and £7,576,855 from other sources, the University of London received £5,484,932 from public and £2,146,915 from other sources; the University of Cambridge similarly received £1,141,350 and £1,161,231; for Oxford the corresponding figures are £1,010,283 and £684,469; for Manchester, £947,752 and £276,832; for Birmingham, £784,576 and £251,156; for Durham, £779,311 and £326,310; for Leeds, £766,052 and £266,472; for Liverpool, £719,115 and £233,220; for Bristol, £684,082 and £313,864; and for Sheffield, £497,520 and £156,079. No other English university or university college had an income exceeding half a million pounds, but all four universities in Scotland exceeded this figure: Aberdeen, with £432,750 from public and £137,453 from other sources; Edinburgh, with £840,906 and £354,792; Glasgow, with £894,950 and £349,042; and St. Andrews, including Dundee University College, with £413,400 and £112,640, respectively. The University of Wales, including the Welsh National School of Medicine, received £900,678 from public funds, and £320,893 from other sources.

Of the total expenditure of £26,132,122, an increase of £2,098,937 on the previous year, administration accounted for 8·8 per cent, departmental maintenance 69·3, maintenance of premises 11·4, and miscellaneous expenditure 9·5 per cent. Capital expenditure met from income amounted to £258,963 and allocations to reserves to £222,536; for 1950–51 these figures were £254,274 and £236,707, respectively. Departmental maintenance included salaries of teaching and research staff and payments for superannuation, the running costs of laboratories, lecture rooms, libraries and museums, and the supply of materials, apparatus, books, specimens, etc. Salaries and superannuation amounted to £12,542,994 compared with £11,895,971 in 1950–51; this represents 48 per cent of the total expenditure compared with 49·1 per cent in 1950–51, with a 4 per cent increase in full-time staff.

Library expenditure, excluding general maintenance of library buildings, etc., rates, heat, light, repairs, etc., amounted to £988,029, or 3·8 per cent of the total expenditure, compared with £891,385 and 3·7 per cent in 1950–51. Of this total, £527,238 was for salaries and wages, £202,567 on account of books, £118,702 on periodicals and £85,087 on bindings. The University of Oxford spent £27,160 on books, Cambridge £11,623 and Manchester £10,924, while a total of £53,730, including £7,478 on the Central Library, £4,787 at the London School of Economics, £5,713 at the School of Oriental and African Studies, and £6,425 at University College, was expended for this purpose in the schools and colleges of the University of London. Ten other universities, Birmingham (£6,574), Bristol (£5,689), Durham (£6,328), Leeds (£7,377), Liverpool (£8,110), Reading (£7,582), Aberdeen (£5,818), Edinburgh (£7,686), Glasgow (£9,326) and St. Andrews (£5,163), spent £5,000 or more on books; and London (£35,435), Oxford (£8,953), Cambridge (£8,641), Glasgow (£8,258) Edinburgh (£5,677) and Manchester (£5,193) spent a similar sum on periodicals. The University of Wales, including the Welsh National School of Medicine, spent £7,987 on books and £6,167 on periodicals.

DUTCH–NORWEGIAN JOINT ESTABLISHMENT FOR NUCLEAR ENERGY RESEARCH

THE Dutch–Norwegian co-operative effort in the field of atomic energy was established in April 1951, and its initial aim was the completion of the heavy-water uranium reactor, Joint Establishment Experimental Pile (JEEP), which was under construction at Kjeller, Norway. In order to further work in atomic energy in the two countries a joint commission consisting of three Norwegian and three Dutch members was set up, and the establishment at Kjeller was incorporated into a Dutch–Norwegian organization called the Joint Establishment for Nuclear Energy Research (J.E.N.E.R.). The first annual report of this organization has now been published*. Mr. Gunnar Randers, who was director of the Norwegian Institute for Atomic Energy (I.F.A.), was appointed director of the Joint Establishment, and, of the original members of the joint commission—Prof. S. Rosseland (chairman), O. Dahl, N. Stephenson, Prof. H. A. Kramers, Prof. C. J. Bakker and J. M. W. Milatz—Prof. Rosseland has since resigned as chairman and been succeeded by Prof. B. Trumpy, and Prof. Kramers has died. Since, however, the creation of the Joint Establishment was largely due to Prof. Kramers's initiative, it is most fitting that the annual report should include a photograph of him as frontispiece and commence with a brief appreciation of his high standing both in scientific circles and in the realm of international affairs.

The factual report is preceded by an extract from a lecture delivered by Mr. Randars on September 26, 1952, at the Technological Institute in Belgrade, Yugoslavia, in which he asserted that, though atomic energy research is undoubtedly an expensive item for small countries to undertake, it would be a mistake to believe that they have a choice as to whether they should undertake it or not. Small countries with large shipping interests—for example, Norway and the Netherlands—cannot afford to have the development of atomic ship propulsion come as a surprise to them, and he maintained that a group of small European nations might well, by joining forces, produce one of the best research and development teams for atomic energy.

Details are given, in the annual report, of the construction and operation of JEEP, which was started up on July 30, 1951. It has a graphite reflector of minimum thickness 70 cm. and uses uranium metal fuel rods contained in aluminium tubes. The reactor was run mostly with a charge of sixty-two rods (about 2·2 tons of uranium); but this is considerably below optimum. The maximum power-level so far developed is 100 kW. with a neutron flux at the centre of the pile of 3×10^{11} neutrons/cm.^{2} sec. The year under review was mainly a 'running-in' period for the pile, and therefore relatively little chemical work was required; but since the pile is well suited, from a technical point of view, for the production of radioisotopes, some research of a chemical nature has been started temporarily by the Isotope Section. It is hoped that when a regular isotope production is achieved at Kjeller, the import and distribution of isotopes from Britain, Canada and the United States, organized by the Joint Establish-

* Joint Establishment for Nuclear Energy Research. First Annual Report, 1951–52. Pp. 26. (J.E.N.E.R., Kjeller, pa. Lillestrøm, 1952.)

ment, will be limited to isotopes and labelled compounds not available at Kjeller.

The work of the Physics Department was concentrated on the acquirement of a thorough theoretical understanding of the operation of the reactor and on the establishment of experimental facilities for research utilizing the neutron flux. Equipment available now includes a rotating velocity selector with spiral channels for the investigation of nuclear reaction cross-sections for thermal neutrons, a pile oscillator, a beta-spectrometer of the short-lens type with no iron core, two mass spectrometers and a ten-channel pulse-height analyser with a resolving time of about 20 μsec. Some preliminary discussions and investigations on new reactor types, with particular reference to ship propulsion reactors, are reported and this work is being continued. A health physicist was appointed to supervise the radiation monitoring programme, and the monitoring instruments which have been in use since the reactor started consist of permanent installations, mainly ionization chambers of the Chalk River type; semi-permanent monitors and portable monitors of the Harwell type; and personal monitoring equipment, dosimeters and films.

The report concludes with a statement of accounts of the Joint Establishment covering the period July 1, 1951–June 30, 1952; a list of personnel in the various departments; and details of the information service, together with references to the scientific articles published by members of the staff of the Establishment during the period under review.

CENSUS OF WOODLANDS IN GREAT BRITAIN

ALMOST interesting report on the census of woodlands in Great Britain has been issued by the Forestry Commission*. The report is based on a comprehensive stocktaking, and this greatly amplifies the information published in 1951 in summary form. The present census was carried out between January 1947 and June 1949, no fewer than 308,000 tabular reports and maps being submitted by parties of trained surveyors. In the report the methods upon which the material collected was classified are detailed. The woodlands are divided into coniferous high forest, broad-leaved high forest, coppice and coppice with standards, scrub, devastated woods and felled woodland. The distribution of the woods will probably cause surprise to many. The counties with the largest woodland areas are: Inverness (212,616 acres), Yorkshire, Hampshire, Perth, Aberdeen, Sussex, Argyll, Kent and Devonshire; while Montgomery has more than any other county in Wales. All counties have some woodland—London, with 639 acres, or 0·9 per cent of its land area, is actually more densely wooded than Caithness.

The data given are separated for the Forestry Commission and private owner, respectively. The total area of woodland in Britain (excluding woodlands less than 5 acres in extent) at September 30, 1947, was 3,448,362 acres, or 6·1 per cent of the land surface of Britain, or only 71 acres of woodland to every 1,000 people. It is stated that Norway has 23·8 per cent of its land surface under trees, Belgium 18·2 per cent, and Denmark 9·3 per cent. As is well known, Britain has the lowest percentages of woodland compared with its land area to be found in Western Europe, excepting Ireland and Holland. The comparison is somewhat misleading. Britain is a small island, densely populated and highly industrialized. Timber is essential to these industries; but foresters and agriculturists realize that all land which can produce crops or feed stock must be utilized by the latter. This of necessity sets the limit to the future area of woodlands; in addition, areas for housebuilding and works have to be eliminated. In each county this matter is now under consideration between those concerned with development and extension of agricultural and forest areas.

The report states that 1,309,569 acres of the total area of woodland were classified in the census as scrub, devastated or felled areas, largely as the result of overfelling during the two World Wars. This figure, says the report, shows the amount of rehabilitation work necessary to restock these areas. There is some difference of opinion upon one type of woodland classified by the Commission as 'scrub'. There are considerable numbers of poor coppice areas in England so classified, and it is true that the coppice is at present in a poor condition. But this is due to the fact that, when the coppice value decreased, the owners failed to continue to replace the old stools as had been done periodically in the past from the time the area had been treated as coppice.

* Forestry Commission. Census Report No. 1: Census of Woodlands, 1947–1949; Woodlands of Five Acres and Over. Pp. 264+11 plates. (London: H.M.S.O., 1952.) 12*s.* 6*d.* net.

JOURNAL OF EMBRYOLOGY AND EXPERIMENTAL MORPHOLOGY

THE first part of a new quarterly journal, the *Journal of Embryology and Experimental Morphology*, devoted to animal morphogenesis has recently appeared*. Its object is to act as a forum for workers mainly interested in developmental processes to be found in animals at any stage of their life-history. Research work to be published in this new journal will include descriptive, experimental, chemical and physiological embryology, regeneration and healing, developmental changes involved in functional adaptation, growth, ageing, and other aspects of late morphogenesis. Studies of gametes and gametogenesis will be considered for publication, provided they are not primarily of a cytological nature; similarly, work on the physiology of reproduction will be accepted provided it does not more appropriately fall within the scope of any other specialized journal. Aspects of protozoology will also be considered which have a bearing on morphogenesis. Papers on developmental processes in plants will receive favourable consideration, too, if they in any way assist in clarifying zoological aspects of morphogenesis.

The new journal will concentrate mainly on finished pieces of research. This means that the papers published will contain sufficient data, tables and illustrations to make clear the authors' results and conclusions. Preliminary reports and theses, therefore, will not be favourably considered for publication; neither will very long papers. It is hoped, nevertheless, when space permits, to publish theoretical and review papers.

* *Journal of Embryology and Experimental Morphology*. (Oxford University Press, Amen House, London, E.C.4.) £4 4*s.* yearly; 25*s.* separate issue.

Contributions may be in English, French or German.

Such a journal is to be welcomed, especially since a strong editorial board of zoologists, anatomists and embryologists has been appointed. It will no doubt relieve congestion in other journals, and will prove invaluable as a platform for discussion, especially among those scientific research workers interested in the rapidly advancing field of morphogenesis—biological, medical, veterinary, agricultural and so forth. British members of the editorial board include such authorities as M. Abercrombie, G. R. de Beer, J. D. Boyd, F. W. R. Brambell, Honor B. Fell, W. J. Hamilton, Sidnie M. Manton, P. B. Medawar, D. R. Newth, C. H. Waddington, J. Z. Young and S. Zuckerman. Other countries are represented on the board by the following: J. Brachet, A. Dalcq, J. Pasteels (Belgium); E. Fauré-Fremiet, Et. C. Wolff (France); J. Holtfreter (United States); S. Hörstadius (Sweden); F. E. Lehmann (Switzerland); Chr. P. Raven and M. W. Woerdeman (Holland); A. Stefanelli (Italy); S. Toivonen (Finland).

Papers in the first (March 1953) issue, which follow a foreword written by A. M. Dalcq in the form of an essay on development, are: J. Pasteels: "Les effets de la centrifugation sur la blastula et la jeune gastrula des Amphibiens. (1) Mécanisme de la formation des organes secondaires aux dépens de l'ectoblaste"; R. M. Clayton: "Distribution of Antigens in the Developing Newt Embryo"; H. V. Brøndsted: "Rate of Regeneration in Planarians after Starvation"; A. and H. V. Brøndsted: "The Acceleration of Regeneration in Starved Planarians by Ribonucleic Acid"; Et. Wolff, K. Haffen, M. Kieny and Em. Wolff: "Essais de cultures *in vitro* d'organes embryonnaires en milieux synthétiques"; J. C. van de Kamer and A. J. Schuurmans: "Development and Structure of the Saccus Vasculosus of *Scylliorhinus caniculus* (L.)".

The editor of the *Journal of Embryology and Experimental Morphogenesis* is Michael Abercrombie, Department of Anatomy, University College, Gower Street, London, W.C.1, to whom all editorial communications should be sent.

ATMOSPHERIC OZONE AND THE UPPER-AIR CONDITIONS

THE amount of ozone in the atmosphere is very small, amounting to a layer less than 3 mm. thick at normal temperature and pressure. The ozone is nearly all in the stratosphere at heights between 20 and 40 km. and is of great importance as it absorbs almost all the solar ultra-violet radiation. Dobson showed in 1929 that over Britain the total amount of ozone changed with the surface pressure distribution; the ozone amount was found to be high on the western sides of depressions and low over anticyclones. This relation did not hold everywhere, and it was suggested that the true connexion was with the state of the atmosphere at high levels rather than that near the ground.

The latest researches into the subject are clearly described by Sir Charles Normand in his 1952 presidential address to the Royal Meteorological Society, which has now been published (*Quart. J. Roy. Met. Soc.*, **79**, No. 339, 39; 1953). Observing at Oxford with the Dobson spectrophotometer, which permits observations of ozone amount to be made even when the sky is overcast with low cloud, he has found a close inverse correlation between ozone amount and the height of the 300-mb. isobaric surface, the thickness of the layer between 500 and 300 mb., and the height of the top of the troposphere—the tropopause. The connexion between them and ozone amount is very close, extending to variations taking less than a day to complete.

Besides reporting the result, Sir Charles discusses the origin. It was at one time thought that the relation between ozone and surface pressure distribution is due to horizontal motion of stratospheric air of high or low ozone content; but, though this may well be important during spring, when ozone increases from south to north, it cannot play a significant part during autumn, when there is very little latitudinal variation of ozone. Sir Charles sees the main reason for the relation between ozone amount and the meteorology of the upper troposphere in vertical motion in the stratosphere associated with rising or falling tropopause. As nearly all the ozone is in the stratosphere, it is clear that, provided formation and dissociation of ozone are sufficiently slow, convergence will bring about an increase in the total ozone content in a vertical column and divergence a decrease. Below 35 km. the mass of ozone in a given mass of air (ozone mixing ratio) changes very slowly, and there is convergence in the stratosphere when the tropopause sinks.

Using available information on the vertical distribution of ozone, Sir Charles shows quantitatively that this explanation is reasonable. He looks forward to more accurate information in future both on the vertical and horizontal distributions of ozone which will make the result more definite. This information is expected from the observations of a network of Dobson spectrophotometers now being set up from Spitzbergen to the Azores and Spain under the auspices of the Ozone Commission of the International Union for Geodesy and Geophysics.

DETERMINATION OF THE POSITION OF A RADIO STAR

A PAPER entitled "The Determination of the Position of a Radio Star" by F. G. Smith (*Mon. Not. Roy. Astro. Soc.*, **112**, 5; 1952), describing work carried out as part of a programme of the radio research at the Cavendish Laboratory, Cambridge, gives a description of a number of new methods of using the spaced-aerial interferometer and compares their accuracies with those of older methods. Four of the possible methods are dealt with—the periodicity interferometer, the crossed-axis interferometer, the variable-axis interferometer and the double-transit interferometer—and each of these is examined in turn.

It is pointed out that the new methods are particularly applicable to the accurate determinations of the positions of intense radio stars; when the object of the observations is to detect the largest possible number of radio stars, the periodicity interferometer has advantages for declinations greater than about 30°, while the crossed-axis interferometer has advantages at lower declinations. Appreciable refraction may occur at radio wave-lengths in the troposphere and also in the ionosphere; in the former the refraction makes the star appear nearer the zenith than it actually is, and as the refractive index of dry air is practically the same for radio waves as

for light waves, the refraction effects correspond closely to the standard astronomical effects.

The refractive index of water vapour is greater at radio wave-lengths than at visual wave-lengths, and hence appreciable deviations at large zenith angles may be caused by a rapid gradient of refractive index caused by a rapid lapse-rate of water vapour. This problem has been dealt with in the Physical and Meteorological Societies' Report (1947); a quotation from a publication shows the magnitude of the correction that is necessary. The total atmospheric refraction at an elevation of 5° was calculated to be 15′, one-third of which was due to water vapour. Irregular ionospheric diffractions occur and are accompanied by changes in the apparent position of the radio star, and this position may vary in a few seconds by 1–2′ of arc on a wave-length of 3·7 m. In addition, regular ionospheric refraction takes place, and the simultaneous reception of radiation from two nearby stars may be responsible for confusion, the resulting error from which is discussed near the end of the paper.

INSTITUTE OF PHYSICS

ANNUAL GENERAL MEETING

At the thirty-third annual general meeting of the Institute of Physics, held on May 29 at Bournemouth, during the second Convention of the Institute, the following were elected to take office on October 1: *President*, Dr. C. Sykes; *Vice-President*, Prof. F. A. Vick; *Hon. Treasurer*, Dr. S. Whitehead; *Hon. Secretary*, Dr. B. P. Dudding; *New Ordinary Members of the Board*, Mr. A. T. Pickles and Dr. P. S. H. Henry. Prof. A. M. Tyndall, a founder Fellow and past-president of the Institute, formerly professor of physics at the University of Bristol, and distinguished for his fundamental work on the mobility of ions and for his services to science and education, was elected to honorary fellowship of the Institute.

The thirty-third annual report of the Board, covering the work of the Institute during 1952, was adopted at the meeting. It records that the Board met six times, and its various standing committees twenty-three times, during the year. The membership increased by 267 to 4,357; but there were small decreases in the numbers of subscribers and student members. The total of those elected to grades of membership for which approved academic qualifications in physics are demanded was the highest since the foundation of the Institute. During the year, the first examination for the recently established graduateship grade took place; twenty-one candidates presented themselves and six satisfied the examiners. The annual report refers to the large increase in interest shown both by employers and colleagues in the National Certificates in Applied Physics. Some slight alterations in the regulations governing these Certificates have recently been made by the joint committee of the Ministry of Education and the Institute responsible for the award and control of the courses. In particular, a practical examination need no longer be held as part of the final assessed examination. For the 1952 examinations there were 137 candidates for the Ordinary and 33 for the Higher Certificate.

About half the work of the Institute is now devoted to its publications, and the magnitude and value of this work can be judged by the fact that receipts from sales, including advertisement revenue, were £28,000 during 1952. The circulation of both the Institute's journals, the *Journal of Scientific Instruments* and the *British Journal of Applied Physics*, continues to increase steadily. The amount of material submitted to the journals in 1952 was similar to that in 1951, but the number of special articles and reports in the *Journal of Scientific Instruments* was rather less than formerly, with more space devoted to original papers. Several new features were introduced into the monthly *Bulletin* circulated to all members; these include invited articles and an annual index. New volumes published during 1952 in the "Physics in Industry" series were "Industrial Magnetic Testing" by Prof. N. F. Astbury and "Metallurgical Equilibrium Diagrams" by Dr. W. Hume-Rothery, Mr. J. W. Christian and Mr. W. B. Pearson. Another interesting publication, "Physics as a Career", written by Mr. N. Clarke, deputy secretary of the Institute, at the suggestion of the Institute's Education Committee, is a guide to the available avenues of training leading to professional recognition as a physicist. A companion volume is the report, "The Scientific Education of Physicists", issued by the Education Committee. This contains details of the physics departments of all the universities and university colleges of Great Britain and of the technical colleges recognized by the Institute. An additional report entitled "Problems concerning the Education of Physicists" will be published shortly.

The Institute continues to be represented on many joint committees and bodies, including government committees and those of the Royal Society, the City and Guilds of London Institute and the British Standards Institution.

The fourth in the series of "Physics in Industry" conferences, and the first since the Second World War, was held in Glasgow during June 25–28, 1952. Its theme was "Physics in the Transport, Shipbuilding and Engineering Industries", and its object, as of those earlier in the series, was "to promote the application of physics to industry by bringing to the attention of industrial executive engineers and scientists recent developments in applied physics and by providing opportunities for the interchange of ideas with and among professional scientists". The conference was presided over by Sir Andrew McCance, and about four hundred people attended. Sir Andrew McCance spoke on physics in the service of metallurgy; Sir Robert Watson-Watt on meteorology in industry; Prof. A. M. Robb on applications of physics in naval architecture; Mr. M. G. Bennett and Mr. T. A. Eames on applications of physics in transport; Mr. A. J. Young on automatic control of industrial processes; and Mr. N. Fleming on noise and its suppression. Dr. D. T. N. Williamson gave a public address, with demonstrations, on physics and sound reproduction, and a discussion was held on the education and training of industrial physicists in Scotland. An exhibition of apparatus, instruments and books was held simultaneously at the Royal Technical College, Glasgow, and a catalogue of the exhibition and a handbook of the conference were published. The generous support of the catalogue by the exhibitors resulted in a handsome surplus of close on £1,000 being added to the Endowment Trust Fund of the Institute.

Details of the various activities of the sixteen local branches and specialist subject groups of the Institute are listed in the report. The Australian Branch held a four-day microscopy conference and exhibition in

Melbourne; the Manchester and District Branch were responsible for a one-day conference on textile physics; and the Scottish Branch arranged a course of eight lectures at the University of Glasgow on the development of concepts of physical science and a course of seven lectures at the University of Edinburgh on semiconductors. The Education Group held a joint meeting with the Acoustics Group of the Physical Society and a conference on school and university examinations in physics. The summer meeting of the Electronics Group took place at the Clarendon Laboratory, Oxford. The X-ray Analysis Group celebrated the fortieth anniversary of the discovery of X-ray diffraction by a two-day conference in London followed by a dinner at which Prof. M. von Laue was the principal guest, and the Industrial Spectroscopy Group was responsible for the Third International Spectroscopy Colloquium held at High Leigh, Hoddesdon, at which many scientists from overseas were present.

Further repairs and improvements were carried out to the Institute's House at 47 Belgrave Square, London; the Institute is again indebted to Mr. R. S. Whipple for another generous donation, this time of £500 to the Furnishing Fund.

CALIFORNIA INSTITUTE OF TECHNOLOGY

ANNUAL REPORT FOR 1951-52

THE annual report of the president of the California Institute of Technology for the year ended June 30, 1952 (pp. v+110; from the Institute, Pasadena, California, 1953), reflects the current concern in the United States over the shortage of scientific and engineering man-power, though the policy of limiting the freshmen to 180 each year has kept the Institute freer of fluctuations than most other institutions, and there is evidence of a slight increase in enrolments generally which should improve the supply in a few years time. Concern is also expressed lest higher education should depend upon any one source of financial support, particularly upon Federal funds; but the financial report which, together with those of the secretary, the deans and administrative officers, and of the several Divisions, is appended to the president's report, shows that of income and expenditure on organized research totalling nearly 11·5 million dollars, 9·6 millions came from the Federal Government for the Jet Propulsion Laboratory, the South Californian Co-operative Wind Tunnel, and the Vista Project, while a further 1·3 millions was received and spent on other research contracts. Gifts for current operations, however, exceeded 1·2 million dollars, and the president points out that, except for the few projects in such fields as nuclear physics and aeronautics, the educational and research work of the Institute is still mainly supported by private funds.

Among the features of the research during the year is the new technique developed in the Division of Biology by Prof. R. Dulbecco for studying those viruses which attack animal tissue, as compared with those which attack only plants or bacteria. The new synchrotron which has been under construction during the past two years has produced electrons with an energy of 525 MeV., and this beam causes the creation of π-mesons. Active study during the past year of the new unstable sub-atomic particles which occur in the cosmic rays has led to the identification of at least five different types of such particles. In the Division of Chemistry and Chemical Engineering the structure of complex molecules is being determined by the electron-diffraction method and by infra-red spectroscopy. Evidence was obtained during the year that a polypeptide helix without 3·6 amino-acid residues per turn is present not only in some synthetic polypeptides but also in proteins like hair, finger-nail, skin, hæmoglobin and serum albumin. The sequence of amino-acids in proteins continued to be studied by chromatographic analysis, and the emphasis in work in chemical engineering is being gradually changed from the study of the equilibrium thermodynamic properties of fluids at high pressures to that of non-equilibrium phenomena, such as thermal and material transfer, under quiescent and convective conditions.

In the Division of Civil, Electrical and Mechanical Engineering and Aeronautics, application of the Institute's electric analogue computor has led, by means of new electric circuit analogies, to the development of a rapid and general method for the static stress analysis of complex structures. A new research programme on the basic insulation characteristics of rotating machine insulation was started, and a new technique developed for use in the high-speed water tunnel permits the determination of the dynamic force coefficients of submerged bodies. Advances were made in two long-range programmes concerned with turbulence and compressible fluid flow, and in the Division of the Geological Sciences, where earthquake records have been studied for more than twenty years, the recent Tehachapi earthquake and its many after-shocks were fully recorded on a dozen instruments in the Pasadena Laboratory and in several field stations. The shock also focused fresh attention on building design for seismically active regions, and the Division of Engineering is engaged in designing structures having maximum resistance and in predicting the behaviour of a given structure.

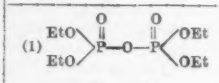
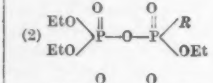
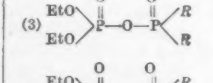
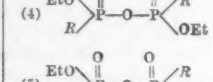
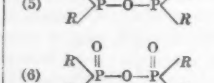
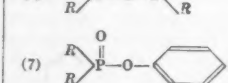
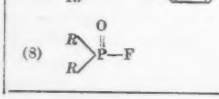
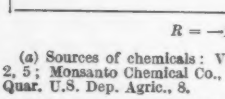
ENZYMATIC AND CHEMICAL OXIDATION OF DIMETHYL-PHOSPHORAMIDES TO BIOLOGICALLY ACTIVE DIMETHYL-PHOSPHORAMIDE OXIDES

By J. E. CASIDA, T. C. ALLEN and M. A. STAHMANN

Departments of Biochemistry and Entomology, University of Wisconsin, Madison

SEVERAL dimethylphosphoramides have been investigated as insecticides, and the group as a whole shows great promise in protecting plants against insect pests by chemotherapeutic action. One of these chemicals, octamethylpyrophosphoramide or 'Schradan', has been developed commercially as a systemic insecticide. These alkylamino phosphates differ from the related toxic alkyl phosphates in that they are generally poor *in vitro* inhibitors of cholinesterase, but nevertheless animals exposed to 2–50 mgm./kgm. show typical symptoms of acetylcholine accumulation[1–4]. Furthermore, these alkylamino phosphates produce a differential *in vivo* inhibition of the peripheral cholinesterase[1,5]. They are relatively ineffective inhibitors of chymotrypsin[6].

ENHANCEMENT IN INHIBITORY ACTIVITY OF DIMETHYLPHOSPHORAMIDES BY LIVER SLICES AND PERMANGANATE

Chemicals (*a*)	Rel. hydrolysis, rate (*b*)	Relative effectiveness as chymotrypsin inhibitor (*c*)	Change in effectiveness (*d*) after reaction with: liver slices (*e*)	Change in effectiveness (*d*) after reaction with: neutral MnO_4^- (*f*)
(1) 	5·0	4·7	− − −	− −
(2) 	2·9	3·5	− −	−
(3) 	2·8	2·8	−	+
(4) 	2·7	2·4	−	+
(5) 	1·8	<0·1	+ + +	+ + + +
(6) 	0	<0·1	+ + + +	+ + + +
(7) 	—	0·5	+ +	+ + +
(8) 	—	<0·1	+ +	+ + +

$R = -N(CH_3)_2$ EtO = $-OC_2H_5$

(*a*) Sources of chemicals: Victor Chemical Co., 1, 7; Bayer–I. G. Farbenindustrie, 2, 5; Monsanto Chemical Co., 3, 4, 6; and Dr. F. I. Edwards, Bur. Ent. and Plant Quar. U.S. Dep. Agric., 8.

(*b*) Measured manometrically at 37° C. and *p*H 7·4; half-life of first chemical 2·7 hr.; other chemicals expressed as the logarithm of the relative hydrolysis rate based on 5·0 for No. 1.

(*c*) Based on negative logarithm of molar concentration required to effect 50 per cent inhibition of esterase activity of 20 γ crystalline chymotrypsin per ml. in *M*/50 phosphate buffer at *p*H 6·25 with 16 hr. combination time at 4° C. prior to assay.

(*d*) Change in inhibitor potency indicated as follows:

− − − = < 1 per cent of original activity
− − = 1–10 " " "
− = 10–80 " " "
+ = 2–10 fold increase in activity
+ + = 10–100 " " "
+ + + = 100–1,000 " " "
+ + + + = 1,000–1,000,000 fold increase in activity

(*e*) 5 ml. *M*/20 phosphoramide incubated with 2·0 gm. fresh rat liver slices in Krebs–Ringer phosphate buffer at *p*H 6·5 for 3 hr. at 37° C. in 100 per cent oxygen atmosphere, then extracted with 10 ml. of chloroform and successive dilutions of the chloroform extract assayed for inhibitor present.

(*f*) 10 ml. *M*/20 phosphoramide incubated with *M*/20 MnO_4^- in *M*/10 phosphate buffer at *p*H 6·5 until MnO_4^- reduced, and then extracted with 10 ml. of chloroform and successive dilutions of the chloroform extract assayed for inhibitor present. (Compound 1 did not reduce the MnO_4^-.)

The dimethyl amide group stabilizes the anhydride bond and makes it very resistant to alkaline hydrolysis[9].

'Schradan' is converted *in vitro* by liver slices[1,2,6], or *in vivo* in mammals or plants[1,9,10] to unstable anti-cholinesterase agent(s)[1], which are effective inhibitors of chymotrypsin[11]. Permanganate oxidation also changed this alkali-stable pyrophosphate to an unstable material capable of inhibiting the enzymatic activity of chymotrypsin[11] and cholinesterase[4]. The active product from this permanganate oxidation was shown to be a compound that phosphorylates the enzymatically active site of chymotrypsin to add one phosphate residue per molecule of chymotrypsin[11]. This chemical oxidation likewise activated *bis*-(dimethylamino)-*p*-nitrophenyl phosphate and *bis*-(dimethylamino)-fluorophosphine oxide[11]. Liver slices were effective in activating the latter compound[4]. The nature of these active substance(s) has not been previously demonstrated.

Our present work is concerned with the chemical nature of the active substances formed biologically from phosphoramides and their relation to the chemical oxidation products. The specificity of this activation is shown in the accompanying table. Permanganate oxidation or incubation with rat liver slices enhanced the acylating reactivity of many dimethylphosphoramides as measured by chymotrypsin inhibition. The initial activity of these compounds as chymotrypsin inhibitors paralleled their relative rates of hydrolysis. A similar correlation has been made with the stability of the anhydride link in dialkyl phosphates and their cholinesterase inhibiting power *in vitro*[12] and in their effectiveness as contact insecticides. The dimethylphosphoramides shown in the table were exposed to neutral permanganate or liver slices in aqueous buffered solutions and the products then extracted into chloroform. Serial dilutions of this chloroform extract were afterwards assayed for chymotrypsin inhibitory activity. As is shown in the last two columns of the table, this activity generally increased by about the same degree with liver slices or permanganate. With octamethylpyrophosphoramide, compound 6, this increase was about one-million fold. Those phosphoramides which showed no increase in activity were the less-stable compounds where the products might have been destroyed prior to partitioning or were poorly extracted into the chloroform. The products of the various reactions were also tested for *in vitro* inhibition of the true cholinesterase of rat brain. The results showed an increased cholinesterase inhibitory activity which generally paralleled the inhibition observed with chymotrypsin.

The nature of the activation of these phosphoramides was further investigated with octamethylpyrophosphoramide or 'Schradan'. The active constituent from its metabolism by rat liver was purified by counter-current distribution utilizing enzymatic assays for determining inhibitor concentration. The active enzyme inhibitor was separated from the bulk of the unmetabolized phosphoramide with three different pairs of solvent systems. The anti-cholinesterase agent produced in plants or by chemical oxidation possessed the same distribution characteristics and activity against cholinesterase and chymotrypsin as that from the rat liver system, indicating the same active product in all cases.

The mode of formation of the active agent, its decomposition to formaldehyde, distribution behaviour, phosphorylating reactivity and biological

specificity indicate that the activation process is an oxidation and strongly suggest an oxidation of a nitrogen atom of the phosphoramide. Further evidence for this was obtained from the infra-red absorption of 'Schradan' following oxidation. Several new absorption bands appeared at almost the identical positions as new bands which are formed when tertiary alkyl amines are oxidized to the amine oxide. Like the amine oxides, the new 'Schradan' oxide obtained biologically or with peracetic acid or permanganate was decomposed on heating in acid to an aldehyde and monomethyl amine. The yield of formaldehyde from permanganate or biologically oxidized 'Schradan' was directly proportional to the cholinesterase inhibition. This oxide of 'Schradan' showed weak basic properties, for it was less readily extracted from acid solutions than from neutral or alkaline solutions by chloroform. The oxidation increased the reactivity of the pyrophosphate anhydride bond to form a reactive phosphorylating agent which was readily hydrolysed by either acid or alkali. This increased chemical reactivity would appear to be due to the new positive centre formed by the oxidation of the phosphoramide nitrogen.

A variety of biological tissues were effective in oxidizing 'Schradan'. In addition to the higher plants, yeast and bacteria also produced the active oxidation product. Many different insects treated with 'Schradan' similarly oxidized the absorbed material. The tissues found most active in this conversion were the gastric cæcæ of the cockroach. The toxicity of 'Schradan' to insects and mammals appeared in all cases to be due to the enzymatic oxidation *in vivo* to yield this highly effective anti-cholinesterase. The widespread distribution of enzyme systems capable of oxidizing 'Schradan' suggests that such systems must have a rather important biological role and that naturally occurring phosphoramides might also be enzymatically oxidized.

Thus, many dimethylphosphoramides are susceptible to enzymatic and chemical oxidation and thus form a new functional group for which we propose the new name 'phosphoramide oxide'. The phosphoramide oxides of phosphoric acid anhydrides are reactive acylating agents and are particularly effective inhibitors of the physiologically important cholinesterase enzymes.

A more complete account of these studies will appear elsewhere.

Publication of this communication is approved by the director of the Wisconsin Agricultural Experiment Station. The investigation was supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation. [Jan. 23.

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INTRA-HELIX S—S LINKED STRUCTURES FOR INSULIN

By Dr. U. W. ARNDT and Dr. D. P. RILEY
Royal Institution, Albemarle Street, London, W.1

WE have briefly mentioned elsewhere[1] that we have considered some feasible structures for the insulin molecule by combining the amino-acid sequences of Sanger and his co-workers[2] with the α-helix hypothesis of Pauling, Corey and Branson[3] and arrived at a limited number of solutions. As this work was facilitated by the use of the Hartley–Robinson 'Courtauld' atomic models[4] and as we knew that Dr. Conmar Robinson was himself working on the insulin problem, we delayed publishing a fuller account. Dr. Robinson has now published[5] his results, which differ very considerably from our conclusions.

We wish to say, first, that to regard the α-helix as a perfect and immutable structure is to take a much too rigid view, and one that is not required by its chemistry. While, in a synthetic polypeptide composed of a single type of monomer, nearly complete regularity is to be expected, this is no longer so in a natural protein constituted of many different amino-acid residues. Variations in both the angle and translation of the helix are permissible and may be necessitated by the different *R*-groups. Such variations were allowed at the outset by Pauling and Corey, and the characteristic constants of the α-helix are known to vary in the case of the synthetic polypeptides. Our suggestion is that, in the natural proteins, the variations can occur within one and the same chain. In the work to be described here, therefore, we have not hesitated to include apparently distorted structures because of this possibility of distributing the strain over several residues.

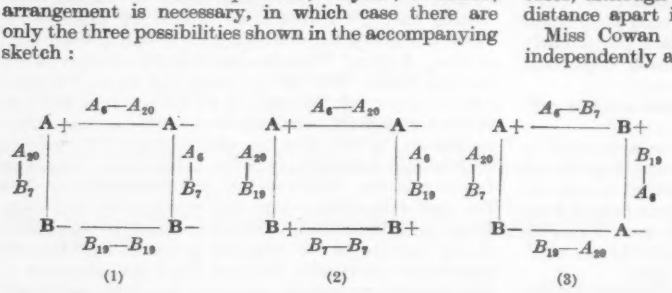
The basis of our present argument is that an intra-helix S—S link exists, and that the insulin molecule consists of two types of polypeptide chains, $\alpha_1(LH,C\beta 2)$ and $\alpha_2(RH,C\beta 1)$, both, of course, containing only L-C_α atoms, as previously described[1a]. These are identified with Sanger's *A* and *B* fractions: $A \equiv \alpha_1$, $B \equiv \alpha_2$. There is some experimental evidence for this view. The X-ray scattering curve for powdered native insulin appears to fit better a mixture of the two possible variants of the α-helix than either separately, while that for the separated *B*-fraction corresponds more closely to the calculated α_2 intensity function alone. We have not yet obtained any data for the *A*-fraction; but the purpose of this communication is not so much to discuss our experimental X-ray results as to propose possible hypothetical structures for insulin deduced from consideration of the spatial properties of the α_1- and α_2-helices. Nevertheless, it may be that the scattering method will have provided the essential clue to the structure of this molecule.

We differ from Dr. Robinson in allowing the formation of an intra-helix S—S link between the seventh and eleventh residues of the *A*-chain. It thereby becomes possible to consider molecules containing fewer inter-helix S—S bridges, and this permits the employment of both types of α-helix. Previously[1a], we stated that the presence of proline imposed the α_2-configuration on any chain in which it occurred. This is only partly true, and we should like here to make a fuller statement.

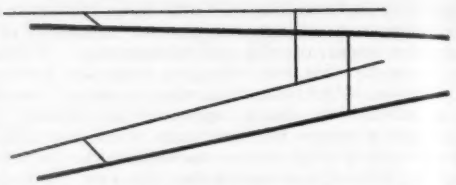
If proline is any one of the first three residues of a polypeptide chain, commencing at the amino end, then the only type of α-helix possible that permits the making of all hydrogen bonds is α_2. Similarly, if proline occurs in the middle of an α-helix, the favoured configuration in the direction of the carboxyl end of the chain will necessarily be α_2. In such a case, on the amino side, the α_2-helix can continue undisturbed for a further three residues only. After this, a disordered (that is, non α-helix) region will arise owing to steric hindrance and the absence of at least one hydrogen bond, and the type of helix, when resumed, is no longer uniquely defined. This disordered region can act as a hinge and permit a change in the direction of the helix axis. In the *B*-chain of insulin, the proline residue is near the carboxyl end of the chain and, therefore, does not necessarily define the configuration in the major part of the helix. Nevertheless, in constructing our models, we have assumed that the whole helix is of the same type, that is, α_2, as suggested by our X-ray data.

It is our belief that the 7–11 S—S link can be made between the C_β atoms in an α_1-type helix if a certain amount of strain and distortion is permissible. A similar link can also be made in an α_2-helix. Approximate figures for the relevant angles and distances are: helix angle, 92°; helix translation per residue, 1·4 A.; H-bond, 2·6 A.; van der Waals radius of —S—, 1·6 A.[6]; C_α—C_β, 1·57 A.; C_β—S, 1·9 A.; S—S, 2·25 A.; ∠ C_α—C_β—S, 115°; ∠ C_β—S—S, 118°. The C_β—S—S—C_β configuration is roughly intermediate between *cis* and *trans*. These values correspond to one possible compromise solution and can be varied, within limits, if the criteria of choice are altered. If the link is made, it is certainly strained and the regularity of the helix over residues 7–11 is disturbed. Therein, according to a speculative view, might in part lie the high biological activity of the molecule.

In order to constitute a molecule of weight 11,550, $2A(\alpha_1)$ and $2B(\alpha_2)$ chains must be cross-linked by four —S—S— bonds involving residues 6 and 20 in the α_1- and residues 7 and 19 in the α_2-helices. From our examination of the problem, a cyclic, or closed, arrangement is necessary, in which case there are only the three possibilities shown in the accompanying sketch:



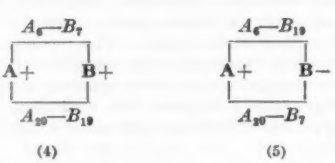
The + and − signs represent the different ends of the polypeptide chains (—NH_2 and —COOH), and all three arrangements are essentially anti-parallel in nature. The third possibility is accompanied by more strain than are the first two. Only one S—S bridge is formed between any pair of neighbouring helices. It is a necessary feature of these hypothetical structures that the four helices lie inclined to one another, the angle between the axes of adjacent helices being approximately 5°. A rough perspective sketch of the disposition in space is given in the accompanying diagram. There appears to be no



Schematic arrangement of helix axes and —S—S— bridges in closed four-chain structures for insulin

steric hindrance whatever between the *R*-groups of adjacent helices, and the nature of the assembly when placed in Sanger's sequences is determined only by the requirements of the four —S—S— bridges across the narrower parts of the molecule. While the molecule has no true symmetry, in a schematic sense its shape is that of a truncated tetragonal sphenoid ($\bar{4}$) the length of which is reasonably accurately defined by that of the longer *B*-chain, 45 A.; its 'diameter' is very roughly 25 A. The average distance between the axes of neighbouring helices is about 11 A.

It is interesting to note, in view of the uncertainty regarding the true molecular weight of insulin, that a 'half' molecule of type *A*—*B* and weight 5,775 can be formed if the intra-helix 7–11 S—S link in the *A*-chain exists. The two helices, with $A \equiv \alpha_1$, $B \equiv \alpha_2$, as before, can be doubly cross-linked in the following ways:



The axes of the helices are nearly parallel in both cases, although some skewness is possible, and their distance apart is about 11 A.

Miss Cowan and Mrs. Crowfoot Hodgkin[7] have independently arrived at a conclusion similar to ours regarding the feasibility of the 7–11 S—S link, and provisionally favour, from the single-crystal data on insulin, a closed 4-chain molecule. The final decision can only come from a detailed analysis of the crystallographic data, but at least there are now several molecular models to be tested which are capable of adequately precise definition.

We should like to acknowledge the aid given to this and related work by the British Empire Cancer Campaign.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Motility of Insect Tracheoles

THE tracheoles supplying the epidermis in *Rhodnius* are simple or branched tubes, 200–350 μ in length, tapering gradually from a diameter of 0·7–0·8 μ to end blindly at about 0·2 μ. Each is laid down within a single cell, the nucleus of which lies at about one-third of the way along the tube. Once laid down, the tracheoles persist unchanged throughout the life of the insect: they do not shed their cuticular linings at moulting, nor are they converted into tracheæ (cf. Keister[1] on the late stages of *Sciara*).

The tracheoles are by no means inert structures. If a region of the epidermis is deprived of its tracheal supply, and particularly if an organ with a high rate of oxygen consumption is implanted, the tracheoles from the adjacent regions migrate towards the oxygen-deficient zone. Movements up to 1 mm. have been observed. The tips of the tracheoles appear to be attracted to sites of low oxygen tension: little effect is produced by a simple incision in the integument if this is exposed to air; but the tips move actively towards a cut exposed to zero oxygen tension (using pyrogallol). The tracheæ may be widely displaced by the traction exerted upon them by the actively moving tracheoles.

It is this migration of tracheoles which provides for the immediate tracheal supply of implanted organs. Afterwards, the low oxygen tension induces an exceedingly active outgrowth of new tracheæ and tracheoles which are filled with air and become functional when moulting takes place.

If the insect is reared in reduced concentrations of oxygen, there is an increase in the numbers of large tracheæ developed. This is particularly evident in the wing lobes. The general pattern of wing venation is not affected by this altered tracheal arrangement, although minor changes may occur. These observations will be published in full elsewhere.

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Observations on *Lebistes reticulatus*

A COMMERCIAL population of *Lebistes reticulatus* was observed for two years and the three following observations were made.

(1) *Exciting action of an extract of domestic flies.* It is known that in its natural habitat *Lebistes* destroys a great many small insects, especially mosquitoes and mosquito larvæ. During the two years we kept this species in an aquarium the fishes were fed on meat and a commercial fish food only.

One day a freshly killed domestic fly was introduced into the aquarium and floated on the surface; the fishes became very excited after a short but clear refractory period. They swam to and fro below the fly and tried to pull it below water and consume it. The following day another fly which had been covered with shellac was introduced into the aquarium, but the reaction was very weak. Visual stimuli therefore appear to play a very small part in this excitation reaction. A few days later some droplets of a colourless extract of about a hundred flies were added to the aquarium water and an intensive reaction followed. It is therefore probable that a water-soluble substance diffused from the fly into the water and is responsible for the reaction observed. Extracts of locusts and caterpillars of *Sphinx convolvuli* and *Mylabris* gave a weak reaction and that of *Dorylus* and *Coprinus* was negative. It therefore seems probable that the exciting factor is fairly specific for the insect concerned. This excitation-provoking substance apparently represents a new group of substances which may be added to the alarm-, smell- and taste-substances examined and described by von Frisch[1].

(2) *Sex-reversion after infectious decimation.* A *Saprolegnia* infection suddenly appeared in the aquarium when it was over-populated, and within three days 70 per cent of the fish had died. The remaining fishes consisted of eighty-six sexually mature females and seven sexually mature males. Within twenty days after the epidemic there were forty-one females which were changing into males, the gonopodia and male colour patterns being almost fully developed. It was noticeable that only the medium-sized sexually mature females showed this change. The small and large sexually mature females were unaffected (see table).

Size (mm.)	No. of males	No. of females	No. of intersexes
19	—	2	—
20	1	1	—
21	—	4	—
22	3	2	—
23	3	2	4
24	—	10	10
25	—	3	7
26	—	2	11
27	—	2	3
28	—	2	2
29	—	3	3
30	—	4	1
31	—	2	—
32	—	1	—
33	—	2	—
34	—	3	—
Totals	7	45	41

The sudden change in sex, twenty days after the epidemic, suggests the probability that the toxins excreted by this pathogenic fungus were responsible for the sex reversion. The question that now arises is: Is the sex reversion a specific reaction to *Saprolegnia* toxins, or may it also occur after poisoning by other toxic agents when they remain active for the same period and with the same intensity?

Other aquaria containing fish of the same population also showed sex reversion, but in a much slighter degree.

(3) *Black mutant with abnormal hydrostatic system.* The same population repeatedly produced a few fish which were characterized by black pigmentation and a reduced swimming capacity. They do not swim horizontally, but with the body at an angle of about 30° with the horizontal, the head being in the highest position. The tail moves very quickly and this gives the impression that they have difficulty in swimming upward because of a hydrostatic defect. In fact, these fishes usually remain just above the bottom

of the aquarium or resting upon it, and never take up a more vertical position to feed from the bottom.

Hitherto, none of these fish has reached sexual maturity. These fish are probably mutants in which the black pigment is intensified, together with an air bladder defect. Often these two factors are accompanied by a slight break in the vertebral column due to which the head bends slightly upwards. In all cases so far observed, the intensification of black pigment and the air bladder defect always occurred together. With care, it seems probable that some of these mutants may attain maturity.

These observations form part of investigations which are supported by a grant of the Council for Scientific and Industrial Research, Pretoria.

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Feb. 10.

[1] Von Frisch, *Z. vergl. Physiol.*, **29**, 1 and 2 (1941).

Fortuitous Xeno-diagnosis of Bat Trypanosomiasis

During an investigation on bat malaria on the East African coast, mosquitoes were fed on infected bats to ascertain the possible course of sporogony of the parasite. The contents of the mid-gut of mosquitoes, fed at various intervals before dissection, were then examined, and instead of ookinetes of malaria, numerous flagellates were found in all the specimens. These included the following:

Nycteris capensis (27)	
Contents of mosquito gut 15 hr. after feed:	Crithidia scanty
" " " " 19 " " "	Crithidia numerous
" " " " 21 " " "	Flagellates numerous
" " " " 40 " " "	Crithidia numerous
Nycteris capensis (28)	
Contents of mosquito gut 11 hr. after feed:	Crithidia numerous
" " " " 18 " " "	Crithidia numerous
" " " " 19 " " "	Crithidia numerous

Trypanosomes in bat blood have been frequently encountered, and in our own investigation the blood of 25 per cent contained these parasites. In bats 27 and 28, however, repeated search of films of peripheral blood failed to reveal trypanosomes; the bone-marrow was likewise negative, but a heart smear of bat 28 exhibited a few trypanosomes.

The trypanosomes were of moderate size and showed small variations in shape and detail (Fig. 1). In Giemsa-stained films, the nucleus was oval and pale (in films subjected to prolonged staining, the nucleus showed an outer paler area surrounding an inner clump of about twelve deeply staining granules), the parabasal body was in the form of a deeply staining bar lying near the nucleus, the cytoplasm was faintly granular and contained 'myonemes', the shape was roughly ventricular with pointed posterior and anterior ends, the undulating membrane was poorly developed and the flagellum was usually prolonged for a short distance beyond the anterior tip. The flagellates (Fig. 2) in the insect were motile and all appeared to be in the crithidial stage. Many dividing forms were seen and there was a great diversity in shape and size.

Little is known about transmission of bat trypanosomes; mites have been incriminated on a few occasions, but in this study no developmental forms were found in sections of mites or in streblids, nor in a tick fed 24 hr. before dissection. On the other hand, development and multiplication took place very rapidly within the mid-gut of mosquitoes (*Aedes simpsoni* and *A. lineatopennis*), and this fact suggests that a mosquito may be the vector in Nature, probably entailing development in the posterior station.

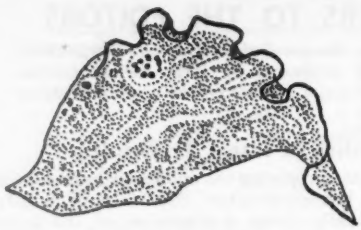

Fig. 1. (× 1,750) Fig. 2

The chief object of this communication is to direct attention to xeno-diagnosis as a means of detection of occult trypanosome infections in bats, a method which is in common use in Chagas's disease for revealing *T. cruzi*. The identity of this bat trypanosome is doubtful, though the dimensions (34–38 μ total length, 14 μ breadth, flagellum not more than 8 μ free) and general characters bring it close to *T. heybergi* Rodhain 1923[1].

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[1] Rodhain, J., *Bull. Soc. Path. Exot.*, **16**, 659 (1923).

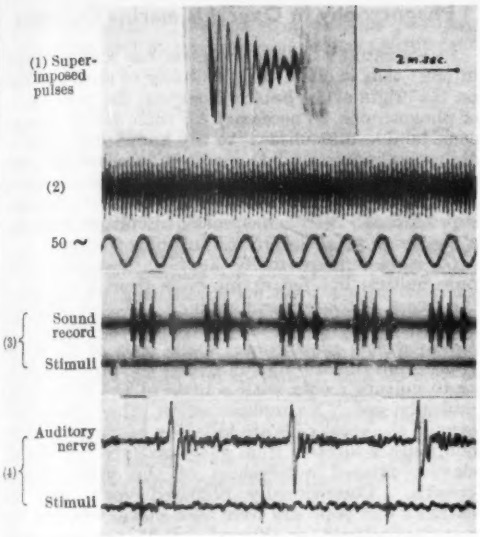
Physiology of Song in Cicadas

Since Myers[1] published his monograph in 1929 on this group of insects, only Pierce[2] has re-investigated the song by modern instrumental methods, and there has been no examination of the physiology of the structures involved in sound production. This communication gives a preliminary report of results obtained with the large *Platypleura capitata*, (Oliv.), in Ceylon.

The normal song of this species is shown in records 1 and 2. The sound consists of a train of damped oscillations at a fundamental frequency of about 4,500 per sec., the pulse repetition frequency being about 390 per sec. Both frequencies vary slightly in individuals and are related to the size of the insect, the internal air cavities being resonant at the fundamental.

The sound is produced by the 'ring' of the tymbals when they are suddenly distorted or return to their normal shape; one of these movements is normally more effective than the other in producing sound, depending on the extent of damping by the tymbal muscle and the resonance of the air cavities. The tymbal muscles contract at each pulse, and act synchronously in full song.

Sound production may be induced in the laboratory by electrical stimulation of the nerve to one tymbal muscle. At low frequencies of stimulation, the muscle responds with a series of contractions to each nerve impulse (record 3), and at stimulus frequencies above about 60 per sec. goes into continuous activity at a frequency which is unrelated to the frequency of stimulation. In this behaviour it resembles the indirect flight muscles of Diptera and Hymenoptera studied by Pringle[3] and Roeder[4]. Since the whole



(2), (3) and (4) are on the same time-scale

structure with its nerve is easily dissected free from the rest of the body, there is here a convenient preparation for the study of this type of muscle.

In the field, the local population of male cicadas normally sing in chorus; but Fabre[5], firing a cannon near a group of insects, was unable to detect any response to the noise. Impulses may readily be detected in the auditory nerve from the tympanal organ of the male or female, which is very sensitive to high-pitched sounds. The response in the auditory nerve of a male to the sound of another cicada played back from a magnetic tape recorder is shown in record 4, the synchronous volleys of nerve impulses corresponding to the pulse frequency, with some after-discharge. This auditory organ therefore behaves like other insect 'ears' in responding to the modulation envelope[6]. During song, the tympanum of the male is creased by the action of a detensor muscle which always contracts before the tymbal comes into operation. This explains Fabre's failure to get any response from a group of singing insects.

This work is being conducted while on leave from the Department of Zoology, Cambridge, and is assisted by a Leverhulme Research Fellowship. Some of the apparatus used was purchased with the help of the Government Grants Committee of the Royal Society. The full results will be published elsewhere.

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Department of Physiology,
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University of Ceylon,
Colombo. April 21.

[1] Myers, J. G., "Insect Singers" (London: Routledge, 1929).
[2] Pierce, G. W., "The Songs of Insects" (Harvard Univ. Press, 1948).
[3] Pringle, J. W. S., *J. Physiol.*, **108**, 226 (1949).
[4] Roeder, K. D., *Biol. Bull.*, **100**, 95 (1951).
[5] Fabre, J. H., "Souvenirs Entomologiques", sér. 5 (1897).
[6] Pumphrey, R. J., *Biol. Rev.*, **15**, 107 (1940).

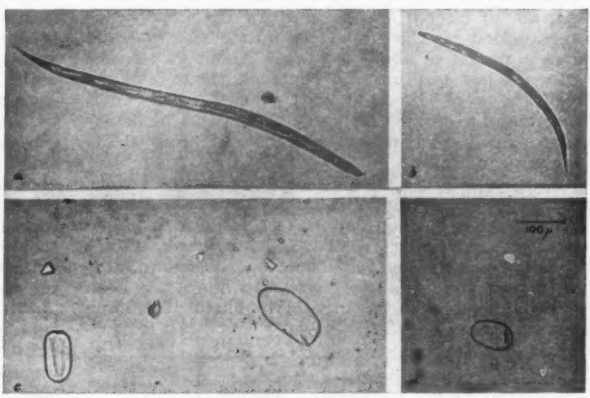
Giant Larvæ of the Potato Root Eelworm, *Heterodera rostochiensis* Wollenweber

It was thought interesting to report the occurrence of a number of giant first-stage larvæ among the progeny of a single female (cyst) of the potato root eelworm. Altogether a total of four giant larvæ emerged on three consecutive days from a single cyst together with a large number of larvæ of normal size. When the cyst contents were examined on the cessation of hatching, no further large larvæ were found, nor any full eggs of unusual size: however, two very large empty egg-cases were noted (Fig. *c*).

	Length (μ)	Breadth (μ)	Stylet length (μ)	Length/breadth
Giant larva 1	817	27	33	25/1
Giant larva 2	783	27	33	24/1
Normal larvæ (mean and S.D.)	463±20·5	18±1·1	24	26/1
Giant egg 1	152	76	—	2/1
Giant egg 2	121	67	—	1·8/1
Normal eggs (mean and S.D.)	103±5	58±5	—	1·8/1

The dimensions of normal and giant larvæ and eggs presented in the accompanying table show that the giants are almost twice the size of normal larvæ. There is little doubt that the large empty cases had been occupied by the giant larvæ, for a rough calculation shows that the volume of the giant larvæ fits that of the large egg-cases fairly well.

So far as I am aware, this is the first record of giant first-stage larvæ in the potato root eelworm,



(*a*) Giant larva; (*b*) normal larva; (*c*) large egg case and normal egg; (*d*) normal egg case. All photographs are to the same scale

or, indeed, in any root eelworm. According to Goodey, Debray and Maupas found large and normal adults of the related stem eelworm, *Anguillulina dipsaci*, attacking broad beans in and around Algiers (original account not available). The larger forms were 30–50 per cent greater than the normal size for this form; this is considerably less than the increase in the present case. These workers suggest that the large forms were due to environmental causes. Goodey found a wholly giant race of the same species, approximately the same size as the large forms of Debray and Maupas, attacking broad beans in Portugal and Great Britain[1]. He showed, in his case, that the larger size was not due to environmental factors.

In the present case, since the giant and normal forms are among the progeny of a single female,

environmental factors can be ruled out. The main possibilities, therefore, are gene mutation and polyploidy. It is hoped that a study of the cell and nuclear size of normal and giant forms will yield further evidence for or against polyploidy.

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[1] Goodey, T., *J. Helm.*, **19**, 114 (1941).

Artificial Infection of Various Molluscs with *Mytilicola intestinalis*, Steuer

Mytilicola intestinalis is common in the mussel, *Mytilus edulis*, at several points around the coast of Britain. It has also been reported from oysters, *Ostrea edulis*[1]. In an effort to determine the conditions governing the infection of oysters, and the extent to which other molluscs may act as a reservoir of *Mytilicola intestinalis*, a number of artificial infections have been attempted.

The potential host molluscs were kept in tanks in 5–15 l. of sea-water in a cool basement (5°–10° C.), with constant aeration, and were fed on a culture of *Chlorella stigmatophora*. With the exception of *Chlamys varia*, no difficulty was experienced in keeping them healthy for at least six weeks.

Copepodid stages of *Mytilicola intestinalis* were obtained by allowing egg-sacs to hatch in about 200 ml. of filtered sea-water at 18° C. Copepodids were added to the tanks containing the molluscs over a period of about a week. About two weeks after the last addition of copepodids, the guts of the molluscs were dissected out, opened along their length and examined for parasites under a binocular microscope. All parasites recovered were 0·25–0·5 mm. in length.

Mytilus edulis, *Ostrea edulis*, *Cardium edule*, *Crepidula fornicata* and *Paphia pullastra* were successfully infected in this manner (see table). Attempts to infect *Scrobicularia plana*, *Chlamys varia*, *Pecten maximus* and *Macoma balthica* were unsuccessful. It is of interest that *Mytilicola orientalis*, Mori, has been reported from a wide range of molluscs[2], including *Paphia staminea* and *Crepidula*.

Host	Sample size	Hosts infected	Total parasites	Maximum parasites per host
Mytilus	20	16	52	7
Cardium	10	4	10	5
Ostrea	16	7	17	6
Paphia	10	7	11	3
Crepidula	13	4	7	3

An intensive examination of oysters from areas adjacent to mussel beds infected with *Mytilicola* has failed to reveal any further natural infection of oysters[1]; but one *Cardium edule* in a batch of twenty examined from Poole, Dorset, contained one female *Mytilicola*, 3·7 mm. in length. An examination of all likely hosts is being made, and further infection experiments are in progress.

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Conway, North Wales. May 28.

[1] Baird, R. H., Bolster, G. C., and Cole, H. A., *Nature*, **168**, 560 (1951).
[2] Odlaugh, T. O., *Trans. Amer. Micr. Soc.*, **65** (4), 311 (1946).

Phagotrophy in *Oxyrrhis marina* Dujardin

Phagotrophy in the Protista has the particular interest that it offers the possibility of shedding light on the origin of the habit. However, the pure culture of phagotrophs, so necessary for their study, presents considerable difficulties; to my knowledge, only one obligate phagotroph has yet been successfully grown thus, *Peranema trichophorum* Ehr.[1]. *Oxyrrhis marina* Dujardin, the common dinoflagellate of the brackish supra-littoral, is extremely easy to culture and offers a challenge to all interested in phagotrophy.

O. marina is normally kept in bacteriologically pure culture but fed at intervals from a culture of the yeast *Saccharomyces exiguus*. It will thrive as well on pure cultures of phytoflagellates such as *Brachiomonas submarina*; single cells of *O. marina* transferred to thriving cultures of the phytoflagellate or to culture media with a little of the living yeast multiply well. No multiplication takes place, however, if the yeast cells are killed by heating up to 70°, and neither filtrates from yeast cultures nor unautoclaved, filtered autolysates of the yeast support growth. Commercially prepared yeast and beef extracts and peptones were ineffective, whether they were autoclaved or filtered. 0·25 per cent milk, pasteurized, will not support growth unless some of the yeast, however little, is introduced also, when cultures of extreme density ensue. On the face of it, therefore, it appears that *O. marina* is an obligate phagotroph and, further, some living cells must be among its food.

In the course of many experiments involving the isolation and washing of single cells and transferring them to media of various descriptions, pure cultures were obtained on two occasions in a liquid medium with particulate nutrients. The successful medium was an autoclaved mixture of yeast and beef extracts with certain B vitamins in addition. In the most successful of the cultures, counts showed that the single cell had multiplied to 250,000, which represents about eighteen generations. All attempts to make subcultures from them met with complete failure, even though an identical medium was employed. It seems, therefore, that the reason for the success of the two cultures did not lie with the known constituents of the medium.

The possibility of chance introductions has to be kept in mind; but the following substances were ineffective: burned or unburned cottonwool, detergents including 'Tween' 80, burned peptone, irradiated peptone, alkali-treated peptone, Evans's peptone, liver infusion, ergosterol, thiamin, riboflavin, niacin, pantothen, pyridoxine, folic acid, *p*-amino benzoic acid, biotin and ascorbic acid. The other possibility is that the single cell with which the cultures started chanced to contain within itself enough reserve of the required substance to supply 250,000 cells.

These experiments demonstrate that *O. marina* need not be dependent on phagotrophy for its gross nutrients. The behaviour is most easily explained by the assumptions that: (1) there are one or more growth-factors to which the cell membrane is impermeable; (2) these factors are present in living but absent from heat-killed cells; and (3) they are required in very small quantity.

An interesting comparison is afforded by *Peranema trichophorum* in which there is obligate phagotrophy but no dependence on living cells for food; this organism can be grown successfully in pure culture on

0·1 per cent milk[1]. It would seem that phagotrophy in *O. marina* and *P. trichophorum* is due to different causes.

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Marine Station,
Millport, Scotland. April 3.

[1] Chen, Y. T., *Quart. J. Micr. Sci.*, **91**, Pt. 3, 279 (1950).

The Australopithecine Milk Canines

We have previously discussed[1,2] the classification of lower milk canines by multivariate statistical analysis. By this means we have shown that the Taungs and Kromdraai specimens found in South Africa are neither those of chimpanzees, gorillas nor orang-utans and that, in tests based on four carefully chosen dimensions of the specimens, they cannot be distinguished from the teeth of humans.

By the courtesy of Mr. J. T. Robinson, we have now been able to apply these methods to six other lower milk canines found in South Africa. One of our tests[1,2] employed the discriminant function,

$$X = x_1 - 7{\cdot}49x_2 + 2{\cdot}34x_3 + 4{\cdot}70x_4,$$

where x_1 is the height, x_2 the maximum anterior–posterior length of the upper half, x_3 the maximum breadth of the upper half, and x_4 the maximum anterior–posterior length at the level of the basal cingulum of the specimen (all measured in millimetres). The values of X for all eight fossil specimens are given in column 1 of the accompanying table. All are negative; that is, all fall outside the range for apes[2] and within the human range. We can therefore conclude definitely that none of these teeth can be assigned to the apes; and, tentatively, that they are of hominid origin.

	X	S
Kromdraai	− 2·6	1·0
Taungs	− 7·9	5·9
Swartkrans *SK* 61 (left)	− 5·9	2·3
Swartkrans *SK* 61 (right)	− 9·1	6·7
Swartkrans *SK* 62	− 7·5	6·7
Swartkrans *SK* 63	− 5·4	4·9
Sterkfontein (left)	− 2·4	11·9
Sterkfontein (right)	− 4·4	10·6

The second conclusion remains tentative so long as the tests are confined to the discriminant X. For the discriminant is essentially a comparative test: a device to decide which of two or more stated alternatives is to be preferred. The analysis was therefore pressed further, to discover how closely, in an absolute sense, these teeth resemble human milk canines.

This question is answered by a second multivariate function, the generalized distance. This statistic sums up, in one quantity, the divergence of the complete set of measurements of the specimen from their means in the group with which it is being compared (making allowances for the variances of the measurements and the correlations between them). It is thus a mathematical measure of the absolute resemblance of the specimen to the group as a whole.

Using the same four dimensions, x_1, x_2, x_3 and x_4, and the same basic material which yielded the discriminant, we constructed[2] such a generalized distance function for human milk canines. Its most convenient form is the sum of squares

$$S = (y_1 - 6{\cdot}53)^2 + (y_2 - 11{\cdot}96)^2 + (y_3 - 4{\cdot}99)^2 + (y_4 - 1{\cdot}91)^2,$$

where the y's are obtained from the x's by the relations

$$y_1 = x_1,$$
$$y_2 = -0{\cdot}345x_1 + 2{\cdot}605x_2,$$
$$y_3 = 0{\cdot}078x_1 - 0{\cdot}586x_2 + 2{\cdot}337x_3,$$
$$y_4 = -0{\cdot}124x_1 - 1{\cdot}159x_2 - 0{\cdot}119x_3 + 2{\cdot}050x_4.$$

The value of S for a specimen is always positive, and the larger S is the smaller is the resemblance to human teeth. On the average, S will exceed 6·0 in only 5 per cent of human specimens; and it will exceed 8·4 in only 1 per cent of human specimens. (These percentages are estimated from the measurements of modern European lower milk canines. It may be expected that they would be somewhat larger if the measurements were extended to include other races.)

The values of S for the South African finds are given in column 2 of the table. They demonstrate the resemblance between these teeth and modern human milk canines. Four values of S lie within the range which encloses 95 per cent of modern human values, and two others lie close to it. The Sterkfontein pair alone is unacceptably remote; a value of S as high as these would be expected to occur in modern European man only once in a thousand times.

For completeness, we should add that the closest resemblance we have found between the individual fossils and the ape groups is between Sterkfontein (left) and the orang-utans, and this corresponds to an S-value of 13·6.

The fossil teeth, it is interesting to note, form a quite compact group. The dimensions x_1, x_2, x_3 and x_4 vary appreciably from one member of the group to another; but we have examined this variation, and it is, in fact, somewhat smaller (though not significantly so) than in our modern human group. The Sterkfontein teeth do not differ significantly from the others within the fossil group, and it seems possible to regard their differences from the human group merely as the outstanding symptom of a general slight departure of the fossils from the human average. The mean dimensions of the fossil group would give an S-value of 4·1, which (since we are now dealing not with an individual result but with the mean of several) is much higher than would be expected if the teeth were all modern human. The difference remains significant if we discard the Sterkfontein finds, and indeed if we confine ourselves to the sub-group of four Swartkrans teeth.

To complete the picture, we examined the resemblances between the mean of the fossil group and each of the ape-groups. We found that the closest resemblance of these was to the orangs, and corresponds to an S-value of 18·9.

To sum up, our analysis shows that the fossil milk canines, on this evidence, form a rather homogeneous group; that as a group they are very similar to those of modern European man; and that they are on the whole unlike those of the modern anthropoid apes.

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[1] Bronowski, J., and Long, W. M., *Nature*, **168**, 794 (1951).
[2] Bronowski, J., and Long, W. M., *Amer. J. Phys. Anthrop.*, **10**, 385 (1952).

Zymasis and Acid Metabolism in Higher Plants

Considerable attention has been directed to zymasis (alcoholic fermentation) as a component of anaerobic metabolism in higher plants; but relatively little is known of the accompanying biochemical disturbances. In many tissues zymasis is suppressed by oxygen in concentrations less than 2 per cent[1]. In air it is normally absent; but certain agents, for example, carbon dioxide in high concentration[2], can induce the accumulation of ethyl alcohol with acetaldehyde.

In plants showing crassulacean acid metabolism, carbon dioxide is fixed into malic acid in a dark reaction[3]. Acid synthesis is promoted by feeding carbon dioxide in concentrations up to 5 per cent; above 10 per cent, acidification is progressively retarded until above 50 per cent it is very slow or stopped and alcohol accumulates[4]. Moreover, acidification occurs only when the oxygen concentration is above about 1 per cent[5].

Inasmuch as the distinguishing characteristic of crassulacean acid metabolism appears to be the potential magnitude of the dark fixation rather than the event itself[4], it seemed possible that the broad correlation between disturbed acid metabolism and onset of zymasis might have some general significance. Exploratory experiments were carried out by chromatographic analysis of the water-soluble components of the plant tissues, and by the comparison of the chromatograms obtained from tissues after storage in one or other of a variety of gas mixtures with those obtained from the normal tissue in air. Aliquots of the aqueous extracts were chromatographed in two dimensions in *tert.* amyl alcohol/formic acid/water, and *n*-propanol/ammonia/water mixtures, or in one direction, after fractionation on ion-exchange resins, in one or other of the solvents.

The broad changes in a limited number of the more prominent components of the chromatograms in a series of experiments with *Kalanchöe* leaves, carrot roots and oat coleoptiles are summarized in the accompanying table. The amino-acid identified as γ-amino-butyric acid co-chromatographed consistently with an authentic specimen (kindly supplied by Dr. S. M. Partridge), and the identity is accepted provisionally.

Plant organ and storage time (20° C.)	Treatment	Citrate	Malate	Succinate	Aspartate	Glutamate	Alanine	γ-Aminobutyrate
Kalanchöe leaves (12 hr.)	*a*	+	+	−	+	+	−	−
	b	+	+	−	+	+	−	−
	c	+	−	+	−	−	−	+
	d	+	+	+	−	−	−	+
Young carrot root (3 days)	*a*	−	+	−	+	+	+	−
	b	−	+	−	+	+	+	−
	c	−	−	+	−	−	−	+
	d	−	+	+	−	−	+	+
Older carrot root (3 days)	*a*	+	+	−	+	+	+	−
	b	+	+	−	+	+	+	−
	c	−	−	+	−	−	−	+
	d	+	+	+	−	−	+	+
Oat coleoptile (1 day)	*a*	−	+	−	+	+	+	−
	b	−	+	−	+	+	+	−
	c	−	−	+	−	−	−	+
	d	−	+	+	−	−	+	+

Occurrence of some acids and amino-acids in plant tissues after storage in gas mixtures: (*a*) air; (*b*) 2–10 per cent carbon dioxide in air; (*c*) 20–90 per cent carbon dioxide with oxygen; (*d*) pure nitrogen, carbon dioxide, or 1 per cent oxygen in nitrogen. + indicates high (relative) concentration, − low concentration.

In concentrations of carbon dioxide less than 10 per cent there was no major change in acid composition. Between 20 and 90 per cent carbon dioxide, succinate and γ-amino-butyrate accumulated, whereas malate, aspartate, glutamate and alanine were depleted. Alcohol accumulation as a result of carbon dioxide zymasis has been observed in many higher plants, but not as yet in concentrations much below 50 per cent[2]. It remains to be seen whether or not more sensitive techniques will detect alcohol accumulation in 20 per cent carbon dioxide.

Zymasis in nitrogen, 1 per cent oxygen, or pure carbon dioxide was accompanied by the accumulation of succinate and γ-amino-butyrate, and the depletion of aspartate and glutamate. Malate and alanine remained unchanged in the storage periods arbitrarily selected for these experiments.

The depletions of the amino-acids suggest parallel changes in the corresponding keto-acids, and this is being investigated.

Carrot and *Kalanchöe* tissues, when aerated in *M*/30 malonate in phosphate at *p*H 4·5, accumulated succinate without appreciable change in citrate or malate. The aspartate, glutamate and alanine contents were not markedly changed; but some γ-amino-butyrate accumulated. Since this amino-acid was present, though to a less extent, in control experiments in phosphate alone, it is possible that the accumulation was not directly attributable to the malonate; but the occurrence of malonate zymasis has been reported recently[6].

Clearly, in the types of zymasis studied, disturbances in acid metabolism occurred, and one result common to all was the accumulation of succinate.

For *Kalanchöe* leaves some indication of the main source of this succinate in carbon dioxide zymasis can be derived from the following experiments. (1) Exposed to carbon dioxide labelled with carbon-14 in the dark at 10° C. for periods of less than 6 hr., these leaves accumulate carbon-14 very largely in malate. (More than 60 per cent of this carbon-14 may be in the β-COOH group.) When leaves containing malate labelled by this treatment were transferred to 70 per cent carbon dioxide, no carbon-14 could be detected in the accumulated succinate or in any alcohol accumulating. The carbon dioxide liberated contained carbon-14. (2) When leaves, in which both sugars and malate were labelled after photosynthesis in carbon-14 dioxide, were transferred to 70 per cent carbon dioxide, carbon-14 was detected in the accumulated succinate and the alcohol fraction as well as in the carbon dioxide evolved. In neither type of experiment was appreciable accumulation of carbon-14 detected in any other acid or amino-acid during the zymasis.

Tentatively it is visualized that, in air, pyruvate is oxidized in a Krebs acid cycle; in carbon dioxide zymasis, (*a*) the accumulated succinate is not in the main derived from malate by a conversion in the acid cycle, (*b*) malate is depleted with decarboxylation to pyruvate, and (*c*) the pooled pyruvate is con-

verted in part to acetaldehyde and ethyl alcohol and in part to succinate.

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Glutamotransferase in the Chick Embryo during Incubation

In recent years the role of glutamine in the metabolism of nitrogenous compounds and in peptide synthesis has attracted increasing attention[1]. Much may be learned about the function of a compound in fundamental biochemical processes by studying the enzymatic system concerned with its metabolism during growth and differentiation. As a first contribution to this problem, we wish to report on the distribution of glutamotransferase in the chick embryo during development. This enzyme catalyses the exchange of the amide group with hydroxylamine or other amines. For full activity, glutamotransferase from mammalian and avian tissue requires manganous salt, phosphate and traces of adenosine triphosphate.

Freshly made homogenates of various embryonic areas or organs in phosphate buffer (0·02 *M*, *p*H 7·3) served as the source of glutamotransferase. Before incubation, no activity could be demonstrated in the fluid yolk, the egg albumen or the vitelline membrane. Likewise we have not been able to demonstrate transferase activity in the unincubated blastoderm, or in the pellucid area during the first and second days of incubation. These negative findings should not be interpreted as necessarily indicating the total absence of the enzyme in these regions.

Unequivocal transferase activity was first demonstrable in the area opaca after incubation for 24 hr. The area opaca and its major derivative, the yolk sac, remain the chief sites of transferase activity until late in the second half of incubation; although, as the embryo differentiates histologically, certain of its tissues acquire a specific activity as high as, or higher than, that of the yolk-sac tissue. The volume of these active tissues (liver, brain and, to a lower degree, heart and stomach) is, however, so slight as to contribute little to the total activity of the embryonic system until considerable growth has taken place.

Protein content and transferase activity were determined on each day of incubation. In the accompanying table the results obtained at the sixth, thirteenth and sixteenth day of incubation in brain, liver and yolk sac are shown; the rest of the tissues of the system embryo minus liver and brain, and other membranes, are grouped as 'remainder', in which only a minimal specific activity is found. The total (100 per cent) was arrived at by summation of the values determined on the individual organs. The following points seem to us the most significant:

(1) Transferase activity increases *pari passu* with protein growth in the total embryonic system. Spatial distribution of the activity, however, is not even, and these inequalities change progressively.

(2) The yolk sac, which begins by containing most of the protein in the system, contributes even more than its share of transferase activity to the whole. This situation is reversed shortly after the thirteenth day of incubation, at which time the yolk sac contributes about 35 per cent of the protein and about half the total activity. After this day, the specific activity of the yolk-sac tissue declines to the general low embryonic level, so that by the sixteenth day this tissue contributes only 17 per cent of the activity, although it contains 26 per cent of the protein.

(3) The liver, when still a minute organ, before its cells start visibly producing bile pigments or storage products, has a specific activity much higher than any other tissue of the system, contributing more than 1 per cent of the total activity when its protein content is considerably less than 1 per cent (six days). Its contribution steadily increases at a rate greater than that of its protein content, thus gradually helping to balance the loss of activity in the yolk sac.

(4) The brain, in contrast, although constituting a major structure of the early embryo, has a low transferase activity, indistinguishable from the general embryonic level, during the first half of incubation. After that time, its activity begins to rise progressively, so that by the end of incubation its contribution to the total activity approximates that of the liver.

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Days of incubation	Tissue	% Protein	% Activity	Specific activity
6	Total	100 (=68 mgm.)	100 (=5·0 μM GHA*)	0·07
	Liver	0·3	1·3	0·31
	Brain	3·3	0·5	0·02
	Remainder	13·4	3·7	0·02
	Yolk sac	83·0	94·5	0·08
13	Total	100 (=635 mgm.)	100 (=42 μM GHA)	0·07
	Liver	3	20	0·45
	Brain	4	6	0·10
	Remainder	58	23	0·06
	Yolk sac	35	51	0·10
16	Total	100 (=1,388 mgm.)	100 (=49 μM GHA)	0·04
	Liver	2·4	30	0·44
	Brain	3	14	0·18
	Remainder	68·6	39	0·02
	Yolk sac	26	17	0·02

* GHA = Glutamohydroxamic acid

The complete assay system contained, per 2 ml. of 0·05 *M* acetate (*p*H 5·5): glutamine 40 micromols, hydroxylamine 20 micromols, phosphate and manganous chloride 10 micromols, adenosine triphosphate 0·1 micromol and an amount of homogenate which permitted the determination of initial rate of glutamotransferase activity. Incubation, 1 hr. at 37°; GHA determined by the ferric chloride reaction (ref. 2) and protein content by the quantitative biuret reaction (ref. 3) or the modified Folin method (ref. 4).

The figures are calculated for one embryo and are expressed as percentage of the total (100 per cent); absolute values of protein content and activity are given in brackets.

Activity: micromols of glutamohydroxamic acid produced in one hour at 37°.

Specific activity: micromols of glutamohydroxamic acid produced per milligram of protein per hr. at 37°.

18 embryos used at six days of incubation, one embryo each at 13 and 16 days.

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Pathway for Glucose Oxidation in *Asterococcus mycoides*

In those species of bacteria examined which oxidize glucose but are incapable of attacking it anaerobically, it has been shown that glucose breakdown proceeds by a pathway other than through the classical Embden–Meyerhof scheme[1]. Cell suspensions of *A. mycoides* (the organism of bovine pleuropneumonia) were found to oxidize glucose, but were incapable of attacking it anaerobically. Consistent with this finding is the fact that growth was almost absent under anaerobic conditions, and was markedly stimulated by aeration of cultures. In spite of the absence of anaerobic glucose breakdown, it is concluded that glucose oxidation in this organism proceeds by way of the Embden–Meyerhof pathway.

Glucose was oxidized by cell suspensions (Q_{O_2}, 60–80) quantitatively to acetate and carbon dioxide. Methylene blue, ferricyanide or diphosphopyridine nucleotide could all replace oxygen as electron acceptor. Pyruvate was oxidatively decarboxylated, and was also attacked anaerobically by the dismutation reaction. Evidence was obtained that the dismutation system was similar to that described in *Escherichia coli* and *Streptococcus fæcalis*[2], that is, a diphosphopyridine nucleotide-linked, pyruvic-lactic dehydrogenase system, requiring coenzyme A, cocarboxylase, magnesium ions and phosphate as acetyl acceptor. Both the oxidation and dismutation of pyruvate were strongly inhibited by arsenite.

Glucose oxidation was inhibited by iodoacetate. Evidence was obtained for the presence of hexokinase. The cells possessed aldolase activity, as determined by alkali-labile phosphate formation in the test system of Sibley and Lehninger[3]. A cell-extract prepared by grinding lyophilized cells with alumina grinding powder had an activity, expressed as μl. hexose diphosphate split per mgm. bacterial protein per hour, of 250. None of the phosphorylated hexose intermediates was oxidized by intact cell-suspensions. Suspensions treated by freezing and thawing, however, oxidized glucose-6-phosphate and hexose diphosphate at approximately the same rate as glucose, but did not attack gluconate or 6-phosphogluconate.

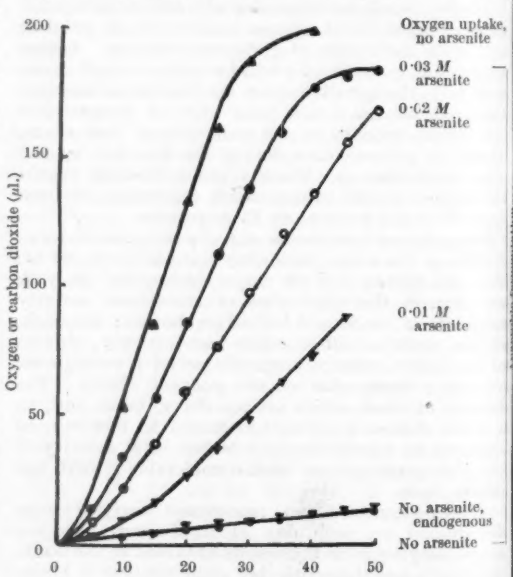
In contrast to intact cell suspensions, suspensions treated by freezing and thawing were capable of a very slow glucose breakdown anaerobically. The rate was very markedly increased when the reaction was linked with the reduction of acetaldehyde by yeast alcohol dehydrogenase (see table). In the presence of arsenite to inhibit the pyruvate dismutation reaction, intact cell-suspensions catalysed a homolactic glucose fermentation at a rate comparable with the rate of glucose oxidation (see graph).

Effect of Linking Anaerobic Glucose Breakdown by *A. mycoides* with Reduction of Acetaldehyde by Yeast Alcohol Dehydrogenase.

Complete system: Frozen and thawed suspension = approx. 1·5 mgm. nitrogen; magnesium chloride, 30 μM; alcohol dehydrogenase solution in $M/20$ phosphate buffer containing 0·1 per cent bovine albumin, 0·4 ml.; glucose, 5 μM; acetaldehyde, 10 μM; sodium bicarbonate, 60 μM; fluid vol., 3·0 ml.; 7 per cent carbon dioxide in nitrogen (v/v) in gas phase

Components	Rate (μl. carbon dioxide/hr.). Experiment 1	Experiment 2
Complete system	135	233
Without alcohol dehydrogenase	59	61
" acetaldehyde	80	120
" alcohol dehydrogenase, acetaldehyde	70	63
" glucose	13	28
" glucose, alcohol dehydrogenase, acetaldehyde	8	26

It was concluded that oxygen (or other electron acceptor) is required for the re-oxidation of reduced diphosphopyridine nucleotide formed by the oxidation of triose phosphate. In the absence of oxygen, pyruvate is bound by the dismutation system, and is not available for reduction to lactate in the glycolysis scheme. The reaction therefore ceases when all the diphosphopyridine nucleotide has been reduced. The organism possesses no other mechanism for the re-



Effect of arsenite on rate of anaerobic glucose breakdown by intact cell suspensions of *A. mycoides*

Anaerobic fermentation: 0·075 M sodium bicarbonate, 0·5 ml.; bacterial suspension, 0·5 ml.; arsenite solution, 0·25 ml.; $M/20$ glucose, 0·1 ml.; water to 2·5 ml. 5 per cent carbon dioxide in nitrogen in gas phase.

Oxidation: $M/5$ phosphate buffer, pH 7·4, 1·5 ml.; bacterial suspension, 0·5 ml.; $M/20$ glucose, 0·1 ml.; 20 per cent potassium hydroxide, 0·2 ml. (centre well)

oxidation of reduced diphosphopyridine nucleotide under anaerobic conditions, for example, α-glycerophosphate dehydrogenase. It must be assumed that, in organisms which are capable of a homolactic fermentation, and which also possess the pyruvate dismutation system—for example, *S. fæcalis*—pyruvate combines preferentially with lactic dehydrogenase. A number of explanations are possible for the different behaviour of *S. fæcalis* and *A. mycoides*, such as the relative affinities of pyruvic oxidase and lactic dehydrogenase for pyruvate; the relative concentrations of the enzymes; or differences in macromolecular organization within the cells. The last possibility is plausible, since cells of *A. mycoides* treated by freezing and thawing are capable of a slow glucose fermentation, and the rate of the pyruvate dismutation reaction is considerably decreased by freezing and thawing.

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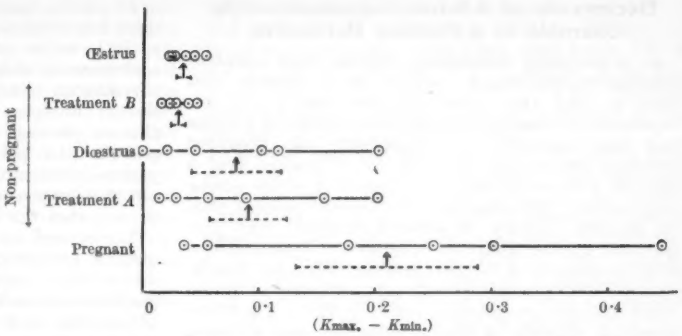
Ultra-Violet Absorption Spectra and Flow Birefringence of Bovine Cervical Secretions

Secretions were collected from around the bovine cervical os using a vaginal speculum and spatula. (It would have been better to use secretions taken from the cervix itself; but such samples were too small for the technique available.) All samples were then reduced to a constant solid content of 0·14 per cent by dispersing in water and clearing in a centrifuge for one hour at about 7,000 *g*. Absorption curves, determined between 200 and 400 mμ, in general showed a maximum at about 273 mμ and a minimum at about 259 mμ.

In view of relationships recently found[1] between the flow properties of these secretions and physiological conditions, the first aim of the present work was to look for similar relationships with the absorption curves. Samples from normal animals during the œstrous cycle and in pregnancy were examined, and also similar types of secretion found in a few heifers already undergoing treatment with mixtures of œstrogen and progesterone. Measurements of the difference between the extinction coefficients at the maximum and at the minimum were taken. This quantity was considered to be more characteristic of the sample than the dimensionless ratio of the two extinction coefficients, since it is less dependent upon scattering and 'general absorption'. Since it has not yet proved possible always to obtain optically clear samples, results showing particularly high 'general absorption' were discarded. The accompanying figure gives a summary of preliminary results on twenty-nine animals.



$K_{max.}$ and $K_{min.}$: extinction coefficients at the maxima and minima on the absorption curves. Arrows represent average values. Broken lines represent standard deviations. Hormone treatment *A*: implants of tablets 30 × 100 mgm. progesterone; 15 × 100 mgm. stilbœstrol. Hormone treatment *B*: injections of 70 mgm. progesterone, 0·5 mgm. hexœstrol per day

In the figure, distinct differences in the average values and distributions of $K_{max.}$–$K_{min.}$ are shown for the œstrous, dicestrous and pregnant types of secretion. Samples from animals in œstrus and which are also under treatment *B* are almost indistinguishable from those in natural œstrus; and secretions from animals undergoing treatment *A* group themselves between the dicestrous and pregnant samples. With the few animals tested so far, no relation has been found between the values of $K_{max.}$–$K_{min.}$ and the duration of pregnancy.

Due to some imperfection in the prism, the slit was open too wide at short wave-lengths. Presumably as a result of scattering, a region of apparent total absorption often appeared at about 215–235 mμ. It was noticed that the width of this region was likewise a function of the physiological condition of the animal, but it is not yet known what physical properties of the secretions this scattering is representing.

Through the courtesy of Dr. A. G. Ogston, I have been able to examine a few similarly prepared samples in his concentric-cylinder flow-birefringence apparatus[2]. Six samples from cows in œstrus showed no sign of birefringence. Of four dicestrous samples, three showed measurable angles of isocline. Six samples from pregnant animals all showed measurable angles.

No attempt has yet been made to interpret these results in terms of the molecular components of secretions; further work is in progress.

I wish to acknowledge the guidance of Dr. G. W. Scott Blair, head of the Physics Department, under whose direction this work was carried out. Thanks are also due to Dr. S. J. Folley for suggestions, and to Mr. D. S. Flux for allowing me to take secretions from animals undergoing hormone treatment in his experiments.

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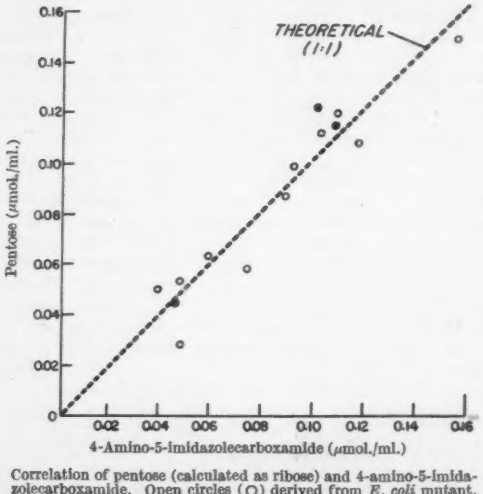
Occurrence of 4-Amino-5-imidazolecarboxamide as a Pentose Derivative

It is becoming increasingly evident that 4-amino-5-imidazolecarboxamide occurs as a riboside and ribotide, and that these pentose derivatives are important intermediates in the biosynthesis of purines and their derivatives. Greenberg[1] has provided evidence that in the biosynthesis of inosinic acid a ribotide is formed before the completion of the purine ring occurs. Schulman and Buchanan[2] showed that the specific activity of isolated inosinate was considerably greater than that of inosine or hypoxanthine after incubation of labelled 4-amino-5-imidazolecarboxamide with pigeon liver extracts, and that inosinate could undergo an exchange reaction at the 2 position involving ribotide of the carboxamide and formate. Greenberg[3,4] has isolated both the riboside and ribotide of 4-amino-5-imidazolecarboxamide from culture fluids of *Escherichia coli* under conditions of sulphonamide bacteriostasis[5]. The enzymatic conversion of the carboxamide to its deoxyriboside has been reported with *Lactobacillus*[6] and *E. coli*[7].

In analysing various *Escherichia coli* systems where 4-amino-5-imidazolecarboxamide is known to accumulate in high concentrations, we have found further evidence for the existence of this compound as a pentose derivative. The majority of the experiments were performed with a purine-requiring mutant of *E. coli*, *B*-96, which accumulates the carboxamide by virtue of a genetic impairment in its conversion to purines[8].

The first evidence which suggests that 4-amino-5-imidazolecarboxamide accumulates as a riboside (or ribotide) in *E. coli* systems is the concomitant occurrence of a pentose, as measured by the orcinol reaction, with the occurrence of the carboxamide as measured by the Bratton–Marshall[9] reaction for diazotizable amines. The results were collected from a wide number and variety of independent experiments and plotted as shown in the graph. Most of the points were obtained from analyses of culture fluids of the purine-requiring mutant, *B*-96, grown under various conditions; a few were obtained from cultures of the wild-type parent strain grown under various conditions of sulphonamide bacteriostasis.



Correlation of pentose (calculated as ribose) and 4-amino-5-imidazolecarboxamide. Open circles (○) derived from *E. coli* mutant, *B*-96, and closed circles (●) derived from parent wild-type *E. coli* *B* under conditions of sulphonamide bacteriostasis

As can be seen in the graph, the points obtained show a definite correlation with the theoretical line for a 1 : 1 molar ratio between 4-amino-5-imidazolecarboxamide and pentose calculated as ribose. Best correlations were obtained from 18–24 hr. cultures. Earlier analyses could not be made because the glucose present in the synthetic inorganic salts-glucose (0·2 per cent) media interfered with the pentose determination. In later cultures, the glucose either disappeared entirely or minor residuals could be adjusted for by the method of Drury[10].

The second evidence is provided by the chromatographic separation of two distinct non-acetylatable diazotizable amines from the culture fluid of the purineless mutant. Culture fluids of the mutant were obtained by centrifugation and run on ascending paper chromatograms with *n*-butanol : diethylene glycol : water (4 : 4 : 1). Examination of the dried paper under ultra-violet light revealed two spots at R_F 0·12 and 0·31. The entire sheet was cut into horizontal strips corresponding in width to an R_F value of 0·05. These were individually eluted with 0·1 *N* hydrochloric acid at 37° C. for 18 hr. Determination of diazotizable amine in the eluates revealed two areas of concentration corresponding to the spots revealed. Synthetic 4-amino-5-imidazolecarboxamide, as the hydrochloride, when similarly treated, gave a single spot at R_F 0·33. The results of a typical experiment are shown in the table.

Paper Chromatographic Distribution of Diazotizable Amines

R_F range	Percentage of total amine	
	Mutant *B*-96	AICA*
0·00–0·05	3·5	0·7
0·05–0·10	25·7	1·0
0·10–0·20	10·1	5·1
0·15–0·20	5·2	7·2
0·20–0·25	8·1	11·2
0·25–0·30	12·0	16·3
0·30–0·35	36·0	56·0
0·35–0·40	1·5	2·4
0·40–1·00	0·0	0·0

* Recovery of synthetic 4-amino-5-imidazolecarboxamide hydrochloride added to supernatant of wild-type *E. coli* *B* culture.

The two separate amines, so obtained, behaved identically with the synthetic carboxamide in terms of coupling-rate after diazotization, colour of diazo dye, spectrum of the dye (absorption peaks at 316 and 540 mμ) and ratio of optical density of the diazo dye at 540 mμ to untreated eluates at 265 mμ. The ultra-violet absorption spectra of the synthetic and the faster-moving material were identical. (E_m at 267 (max.) = $11{\cdot}8 \times 10^3$.) The absorption spectrum of the material with the slower R_F, however, corresponded with that of the others only at wave-lengths greater than 260 mμ. At wave-lengths less than 260 mμ a distinct displacement was found in the direction of a greater absorption by the slower-moving amine. For example, the absorption was 30 per cent greater at 240 and 250 mμ.

An examination of the eluates for pentose showed that 57 per cent of the total pentose present in the original supernatant was associated with the slower-moving amine, the remainder being at the level of the faster-moving amine. Since free ribose, when similarly chromatographed, concentrates at an R_F of 0·37, the latter could represent free ribose resulting from nucleoside cleavage. Chromatographic analysis of 4-amino-5-imidazolecarboxamide and its respective derivatives by Greenberg[4,11] indicates that the amine with the low R_F as described here could indeed be the ribotide, and that with the higher R_F value could

represent the free base or the riboside or a mixture of both. The latter may have resulted from nucleosidase and/or phosphatase activities of the organism. This was strengthened by an additional experiment based on one reported by Greenberg[3,4]. When the amine in the low R_F eluate is subjected to acid hydrolysis, it is converted to a single amine which becomes concentrated entirely at the higher R_F-level.

The evidence presented here concerning the natural occurrence of 4-amino-5-imidazolecarboxamide as a nucleoside or nucleotide serves to strengthen further the concept that, in the biosynthesis of purine derivatives, pentose addition occurs prior to ring closure of the purine nucleus[11].

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An Indirect Polarographic Determination of Calcium

In order to overcome difficulties associated with the direct polarographic determination of calcium, Cohn and Kolthoff[1] employed an indirect approach using picrolonic acid. We have found, however, that chloranilic acid, previously used by Tyner[2] for the colorimetric estimation of calcium, is preferable to picrolonic acid in that it is more sensitive and requires a much shorter reaction-time.

Calcium reacts quantitatively with chloranilic acid, precipitating calcium chloranilate. In solutions neutral to Congo red, the reaction is complete within ten minutes. Calcium may be estimated, without removing the precipitate, by adjusting the *p*H of the solution to 4·5 with universal buffer[3], measuring the polarographic diffusion current of the residual chloranilic acid, and referring the value obtained to a calibration curve. Calcium may thus be determined within a concentration range of $1{\cdot}3\times10^{-4}$–$1{\cdot}2\times10^{-3}$ *M* with a maximum error of approximately ± 3 per cent. When analysing solutions containing an unknown amount of calcium, it is first of all necessary to estimate the calcium roughly by adding 0·5 ml. of the solution to 7·5 ml. of 2×10^{-3} chloranilic acid: the reagent should not be decolorized within ten minutes after the addition of the solution.

The determination cannot be carried out in the presence of cobalt, lead, zinc, manganese, cadmium, nickel, aluminium, copper and silver, since these ions precipitate the reagent. Sodium, potassium, ammonium, magnesium, ferric and mercuric ions do not cause precipitation; but the latter two should not be present in concentrations greater than $4{\cdot}8\times10^{-4}$ *M* and $5{\cdot}9\times10^{-4}$ *M* respectively. Magnesium does not interfere in concentrations lower than $2{\cdot}4\times10^{-3}$ *M*, nor do lithium, barium and chromium when their concentrations are less than $5{\cdot}9\times10^{-4}$ *M*. Strontium does not affect the determination if present in concentrations up to $3{\cdot}6\times10^{-4}$ *M*.

Calcium has been determined in the ash of blood serum and of milk with an accuracy of approximately ± 3 per cent. Recovery experiments and parallel determinations using the oxalate–potassium permanganate method indicate that polarography yields more reliable results. The procedure is not only rapid but is also unaffected by the presence of magnesium and iron in concentrations commonly found in biological materials. Thus calcium can be estimated in blood serum showing marked hæmolysis.

Details of the method will be published elsewhere. We are indebted to Mr. G. Loftus Hills for suggesting this research problem and to the Dairy Section of the Commonwealth Scientific and Industrial Research Organization for financial assistance.

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Mesomeric Effect of the Sulphonic Acid Group

INFORMATION about the effect of the aromatically bonded sulphonic group has been obtained by studying its influence on the reactivity of other substituents of the same molecule. A suitable way is the measurement of acidity constants of phenols, anilinium ions and aromatic carbonic acids. Earlier investigations on these constants for naphthylaminesulphonic acids[1] and naphtholsulphonic acids[2] showed the existence of an electrostatic effect which is due to the dipolar structure and the negative charge of the SO_3^- substituent. A. Bryson, who investigated the naphthylamines, points out that the differences in the *pK*-values provide evidence for the conjugative interaction of the sulphonate ion and the aromatic ring. I was unable to extend this conclusion to the naphtholsulphonic acids.

I therefore investigated derivatives of benzenesulphonic acids and evaluated the measured acidity constants with Hammett's equation for *m*- and *p*-substituted benzenes. The accompanying table shows the results of the potentiometric determination of the *pK*-values in water at an ionic strength

ACIDITY CONSTANTS AND σ-VALUES
(ionic strength $\mu = 0{\cdot}10$; 25° C.)

	pK_1	pK_2	σ_m-SO_3^-	σ_p-SO_3^-
Aniline	4·71			
Metanilic acid		3·65	+ 0·39	
Sulphanilic acid		3·12		+ 0·58
Phenol	9·86			
m-Phenolsulphonic acid		9·07	+ 0·39	
p-Phenolsulphonic acid		8·70		+ 0·58
Benzoic acid	4·09			
m-Sulphobenzoic acid		3·78	+ 0·31	
p-Sulphobenzoic acid		3·72		+ 0·37

$\mu = 0{\cdot}10$ and the σ-values calculated with these constants.

These σ-values of the *m*- and *p*-sulphonic group may be compared with those of the other substituents mentioned in the literature. From the table it is apparent that the effect of the $p\text{-}SO_3^-$ group is not accurately described by a single σ-value. The constant for *p*-sulphobenzoic acid is 0·21 smaller than the values of the constants for sulphanilic acid and *p*-phenolsulphonic acid. Comparable differences have been observed for $p\text{-}NO_2$ (0·49)[3], $p\text{-}CH_3CO$ (0·44)[4], *p*-CN (0·34)[5] and $p\text{-}CH_3SO_2$ (0·42 and 0·26, respectively)[4,6]. By analogy with the interpretation for these substituents, we conclude that there is a conjugative effect in the sulphonic ions, too, and that the sulphur atom in sulphonic acids is capable of extending its octet to a decet (or dodecet) structure.

There is a peculiarity of the σ-constants for *m*- and *p*-sulphonic groups. So far as I know, this is the first negatively charged substituent for which σ-values for several equilibria have been calculated. All other substituents have a net charge of zero: only one of the groups investigated has a positive charge, namely, the trimethylammonium ion studied by Roberts and co-workers[7]. The pK_a-values shown in the table relate to the ionization of a second proton of the molecule (the first, more acidic proton refers to the ionization of the SO_3H group). Therefore the acidity constants of these benzene sulphonic acid derivatives show a different kind of dependence on changes in ionic strength from the unsubstituted compounds phenol, anilinium ion and benzoic acid. This explains why the σ-values for *m*- and $p\text{-}SO_3^-$ (but not for electrically neutral groups) depend in a high degree on the ionic strength. The σ-values calculated from acidity constants at ionic strength $\mu = 0{\cdot}01$ and $0{\cdot}001$ are smaller than those shown in the table. The observed differences of σ-values for the $p\text{-}SO_3^-$ group are important evidence of the mesomeric effect. The acidity constants at low ionic strengths were measured spectrophotometrically in the range 220–255 mμ. A description of the experimental procedure as well as a detailed discussion of the results will be published later in *Helvetica Chimica Acta*.

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March 2.

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Gravity Survey in the Congo

The Service de Météorologie et de Géophysique of the Belgian Congo has started a basic survey of gravity stations, in order to supply a fundamental network to workers engaged in more detailed measurements.

The link with European observatories has been provided by two important pieces of work; the first by Madame Duclaux and M. Martin from Paris, who in 1950 established in this territory nine stations carefully surveyed with a North American gravity meter; the second by M. Sanders, from Uccle Observatory, who in 1951 measured gravity at three of those nine stations by a refined technique using a modified Von Sterneck pendulum instrument. The values found by these workers have been published elsewhere; they are in excellent agreement.

We have used these nine stations to calibrate our North American gravity meter and proceeded to establish the first part of our basic network. This consists of twenty-seven aerodromes where repeated measurements have been made along relatively short overlapping circuits, enabling the observations to be made generally at two or three stations in one or at most two days before returning to base. The survey took place between July and September 1952.

The gravimeter has been fitted with an improved dial, and was transported by air in an air-tight container in which the pressure was maintained at the value it would have at the next station along the circuit. After a short rest, readings were taken by two different procedures: first, by adjusting and reading the dial several times when the index was on the centre of the micrometric scale; secondly, by adjusting and reading the dial for various settings on the micrometric scale. This second method amounts really to determining a very small correction for errors in levelling.

With the above precautions added to the usual technique, it has been possible to attain remarkable consistency in the measurements. The provisional results, in which no corrections for sun and moon tidal variations have been made yet, are given in the accompanying table. A detailed account of the work, and corrected values, will be published shortly.

Aerodromes	Lat.	Long.	Altitude	*g* (cm./sec.²)
Léopoldville*	04° 19′ S.	15° 20′ E.	300 m.	977 918·14
Kikwit	05° 02′	18° 50′	515	905·06
Luluabourg	05° 54′	22° 29′	685	909·87
Kamina	08° 39′	25° 14′	1,085	820·43
Kolwezi	10° 42′	25° 28′	1,465	824·08
Elisabethville	11° 37′	27° 28′	1,271	893·52
Manono	07° 17′	27° 26′	614	894·87
Kindu	02° 58′	25° 52′	515	876·98
Albertville	05° 55′	29° 12′	780	848·70
Usumbura	03° 24′	29° 21′	818	734·83
Kamembe (Bukavu)	02° 27′	28° 54′	1,590	587·88
Kigali	01° 58′	30° 08′	1,500	602·31
Goma	01° 46′	29° 14′	1,530	599·42
Coquilhatville	00° 02′	18° 16′	350	904·68
Basankusu	01° 13′ N.	19° 48′	354	916·99
Lisala	02° 09′	21° 30′	495	851·20
Bumba	02° 11′	22° 27′	385	925·83
Stanleyville	00° 31′	25° 10′	420	883·71
Kongolo	05° 25′ S.	27° 00′	570	881·40
Kasongo	04° 32′	26° 37′	600	885·06
Libenge	03° 38′ N.	18° 38′	395	951·42
Banningville	03° 18′ S.	17° 21′	340	922·18
Nioki	02° 45′	17° 42′	370	937·95
Inongo	01° 57′	18° 17′	320	937·57
Irumu	01° 28′	29° 51′	915	776·57
Matadi	05° 48′	18° 26′	350	966·42
Moanda	05° 56′	12° 21′	15	978 123·18

Root mean square error: 0·10 milligal.
* Binza Observatory (not an aerodrome).

The second part of the basic network will consist of stations selected along the roads which connect the aerodromes already surveyed.

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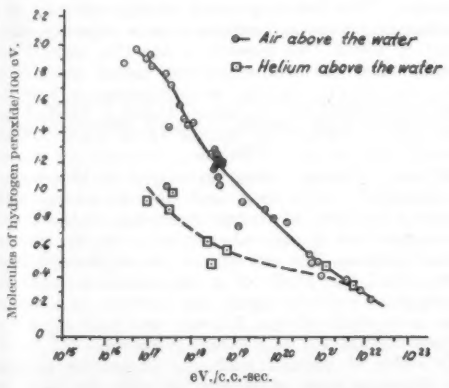
Formation of Hydrogen Peroxide in Water by 1-MeV. Protons

EXPERIMENTS using monoenergetic protons from a Van de Graaff accelerator have been carried out on the formation of hydrogen peroxide in water. The irradiation chamber was of 'Pyrex' glass, including a thin window through which the protons entered. The total volume of water irradiated was 0·4 c.c.; however, the irradiation volume was only $6{\cdot}9 \times 10^{-4}$ c.c., because of the short range of the protons in the sample. The absolute amount of hydrogen peroxide which is formed does not change when the total amount of water is varied from 0·2 to 0·5 c.c. The chemical determinations were made with a Beckman model *B* spectrophotometer at 3500 A. utilizing the iodide method suggested by Ghormley[1]; this method is capable of measuring 2×10^{16} molecules of hydrogen peroxide per litre. The water was freshly prepared by redistillation from a permanganate solution with a 'Pyrex' still.

For each determination the total energy input into the water was about 10^{18} eV. At the rate of $3{\cdot}3 \times 10^{19}$ eV./c.c.-sec., the amount of hydrogen peroxide formed was linear with dose up to a total input of 10^{19} eV.; at the rate $3{\cdot}5 \times 10^{19}$ eV./c.c.-sec., the amount of hydrogen peroxide formed was linear with dose at least to 5×10^{19} eV. All the rates of energy input refer to the irradiation volume of $6{\cdot}9 \times 10^{-4}$ c.c.

The efficiency of the formation of hydrogen peroxide by 0·95-MeV. protons is found to be highly dependent upon the rate of energy input. When the dose-rate is varied from 2×10^{16} eV./c.c.-sec. to 10^{22} eV./c.c.-sec. with air-saturated water, the efficiency decreases from 2·0 molecules hydrogen peroxide/100 eV. to 0·3 molecule hydrogen peroxide/100 eV., as shown in the graph. The results also show that the exclusion of air in and over the water by a helium atmosphere (less than 0·05 per cent oxygen) reduces the efficiency of formation of hydrogen peroxide by a factor of two at 10^{17} eV./c.c.-sec., but at 10^{21} eV./c.c.-sec. the efficiency is not changed by the absence of dissolved air in the water.

The observations suggest the following conclusions: (1) The formation (or the formation and destruction) of hydrogen peroxide in water is dependent upon the rate of energy dissipation per unit volume of the incident radiation. (2) 1-MeV. protons are intermediate in behaviour between alpha-particles and X-rays, as one might expect from the comparative linear ion densities. In oxygen-free water, alpha-particles and protons produce hydrogen peroxide; however, the presence of dissolved oxygen increases the efficiency of hydrogen peroxide formation with protons except with very high dose-rates. (3) It seems likely that the efficiency of formation of hydrogen peroxide does not continue to increase as the dose-rate is decreased below 10^{17} eV./c.c.-sec. For example, in the region of 5×10^{15} eV./c.c.-sec., Bonet-Maury[2] found that the efficiency of production of hydrogen peroxide by 13-kV. X-rays with dissolved air in the water becomes greater with increasing dose-rate. These two results suggest that a maximum in the efficiency of production of hydrogen peroxide may exist in the region of 10^{15}–10^{17} eV./c.c.-sec., the exact position of the maximum depending on the linear ion density of the ionizing particles.



Yield of hydrogen peroxide in water vs. the rate of energy loss per unit volume by protons

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Stability and Settling of Dispersions of Carbon in Organic Media

IN an investigation of the action of detergent additives in engine lubricating oils, the sedimentation behaviour of suspensions of carbon black in a wide range of organic media has been studied. Suspensions were prepared by dispersing 0·5 gm. of carbon black ('Micronex') in 25 ml. of the liquid by means of 19 kc./s. ultrasonic vibration. The sedimentation behaviour of such systems falls into two distinct classes, depending on the detergent properties of the liquid.

Class (1) includes the majority of pure organic liquids and solutions of weakly detergent additives in hydrocarbons, and is characterized by a settling process which involves the formation of a sharply defined interface between supernatant clear liquid and opaque dispersion. The sedimentation process follows the equation:

$$\ln [(V_t - V_\infty)/(V_0 - V_\infty)] = -Kt, \qquad (1)$$

where V_0 is the initial volume of the dispersion, V_t is the volume occupied by suspended material at time t, V_∞ is the final volume occupied by the suspension, and K is a constant the value of which is dependent on the nature of the liquid and may be used to assess its detergent properties. It follows from equation (1) that the particle velocity during sedimentation is a function of the shape of the vessel, and thus this sedimentation process differs radically from conventional concepts of settling of particles in liquids. The settling is complete in times of the order of 24 hr., and the final volume occupied by the sediment is of the order of 10–15 ml.

Class (2) comprises systems in which the entire liquid phase is always uniformly opaque. In some of these systems a deposit of sediment may gradually settle to the bottom of the vessel. As the deposit accumulates, so the opacity of the supernatant suspension decreases. The times involved are of the order of several months, and the final volume occupied by the sediment is only of the order of 1 ml. With other solutions, including those of the most strongly

detergent lubricating oil additives, and also with certain very polar organic liquids such as nitrobenzene and aniline, no sedimentation has been observed over periods of many months.

The explanation of these phenomena can be based on hindered aggregation under Brownian motion of the particles[1]. In the systems of class (1) it is postulated that aggregation results in the formation of a chain-and-scaffolding structure of particles and aggregates. This lattice-like structure extends throughout the entire volume of the dispersion, and traps suspension within voids. Continued aggregation of enmeshed but suspended particles on to the network causes its collapse through overweight. The collapsing network thus gives rise to the sharp interface, since the probability of an individual particle escaping from a void into the supernatant liquid is very small compared to its probability of aggregating on to the lattice during its motion towards the interface.

Consideration of the rate of diffusion of particles to the network under Brownian motion leads to equation (1) above, with

$$K = (kD/\overline{x^2}) \exp(-E/RT), \qquad (2)$$

where k is a constant dependent on the geometrical arrangement of particles and network, D is the diffusion coefficient for the particles, $\overline{x^2}$ the mean square distance of a particle from the network, and E is the magnitude of an energy barrier to aggregation.

The energy barrier arises from the work involved in expelling liquid, against surface forces, from between the coagulating particles.

Thus:

$$K = (kD/\overline{x^2}) \exp(-X\rho\gamma/RT), \qquad (3)$$

where ρ is the density of the liquid, γ the interfacial tension and X a constant dependent on the volume of liquid expelled. If $\ln(kD/\overline{x^2})$ is small compared to $\ln K$, equation (3) predicts that a plot of $\ln K$ against $\rho\gamma$ for different liquids should be a straight line with a negative slope. Experiments with a wide range of pure organic liquids and binary mixtures have confirmed that this relation holds when values of γ for the liquid-air interface are used[2].

Solutions of surface-active additives follow equation (1), but cannot be correlated by equation (3) because it is not possible to state what values of ρ and γ should be used for the material adsorbed at the carbon – liquid interface. It is possible that the persistence of the network structure is responsible for the large final sediment volumes exhibited by these systems, which are many times the 'dry' volume of the carbon.

In the systems of class (2) the energy barrier to aggregation may be so large that significant aggregation can never take place. This is confirmed by the large value of $(\rho\gamma)$ for nitrobenzene and aniline. On the other hand, with less stable systems sedimentation occurs, but the rate of growth of aggregates is not sufficient to give rise to the lattice network. The aggregates are able to settle unhindered under Stokes's law.

Electrical phenomena at the carbon – liquid interface contribute to the energy barrier to aggregation. Electrophoresis, electro-osmosis and sedimentation potentials have been demonstrated in the systems[3]. If a stable suspension which exhibits electrophoresis of the particles to the anode is mixed with a stable suspension which exhibits cataphoresis, then a very rapid mutual coagulation takes place.

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A Double-Beam System for Infra-Red Spectrometers employing Rotating Twin Cells

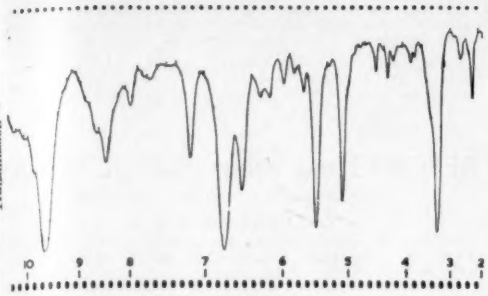
The desirability of using direct-ratio instruments for the recording of infra-red spectra is immediately obvious when one considers the labour involved in measuring energy curves with the customary 'cell in—cell out' technique, and then carrying out the corresponding point-by-point division necessary to obtain a spectrum of percentage transmission versus wave-length. There are also the attendant difficulties arising from possible variations in source intensity or in atmospheric absorption between two consecutive runs. An instrument which performs these functions automatically must be capable of viewing the radiant energy passing through both the sample and standard cells simultaneously.

These requirements have been satisfactorily fulfilled by a number of double-beam instruments described in the literature. However, it is true to say that, in general, the systems involved are either of special design in costly commercial apparatus, or else have entailed very expensive optical and electronic modification of single-beam instruments. A previous suggestion for a simple instrument has been published but was later withdrawn[1].

A simple double-beam attachment for a standard single-beam instrument (Perkin Elmer Model 12C) can be built at little cost. No optical modification is needed and a minimum of additional electronic equipment is required for the existing set-up.

The method employed is essentially an alternating beam system used in conjunction with a voltage ratio recorder. The beam-splitting system consists of a demountable twin cell arranged as a rotating sector wheel of which two quadrants are the control and sample cells, the others forming metal shutters so that the output to the monochromator has the following sequence: I_0 beam through control cell (1/26 sec.), blocked by shutter (1/26 sec.), I beam through sample cell (1/26 sec.), blocked by shutter (1/26 sec.), thus providing an output at 13 c./sec. at the detector. The twin cell unit is conveniently mounted in front of the entrance slit of the monochromator and is the only addition to the present optical system. The cell unit is driven through bevel gears from the shaft of a synchronous contactor arranged to provide signal rectification and separation, zero shift of the I beam and test signals of known voltage for calibration purposes.

In order to provide sufficient output to energize the low-resistance slide-wire of the recorder, an additional power amplifier unit has been included. The existing Brown recorder has been used with an



additional slide-wire to permit its use as a ratio recorder without impairing its use for single-beam operation. The Perkin Elmer string-slit drive has also been retained and provides a sufficiently constant energy-level for the system which is not dependent on a strict control of the I_0 signal.

Finally, the whole system has been so arranged that a return to single-beam working may be made immediately by removing the twin cell unit and isolating the additional electronic equipment by a simple switch.

Although the system has not been long in operation, satisfactory results have been obtained comparable with those given by the conventional commercial double-beam instruments. As an example, the instrument record of the infra-red spectrum of benzene in carbon tetrachloride solution measured in a 100-μ cell over the wave-length range 2–10 μ is reproduced herewith. It will be noted that the sharp absorption bands in the 5–7-μ atmospheric water-vapour region are readily resolved.

Full details of this method, which may also be applied to visible and ultra-violet spectrometers, will be described elsewhere at a later date. We thank the President, Council and Director of the Research Association of British Paint, Colour and Varnish Manufacturers for permission to publish this communication; also Mr. E. W. M. Fawcett for his advice and guidance.

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A Method for the Determination of the Approximate Surface Areas of Particulate Solids

A method I have devised for the determination of the approximate surface areas of particles involves the determination of the relationship between moisture content (v) and suction pressure (h). Graphical integration of this function gives the work done during withdrawal of water, and, provided the process is carried out isothermally, this work is equal to the increase in the surface free-energy of the water. Hence the increase in surface area of the water is given by:

$$\Delta A = \frac{1}{\gamma} \int h.dv,$$

where γ is the surface tension of water. Provided that the contact angle between water and the solid is zero, and that a sufficiently large suction can be applied, this area approximates very closely to that of the solid.

A method based on the same principle, but measuring the thermal energy liberated when a liquid surface surrounding a solid is destroyed adiabatically on immersion, has been developed by Harkins and Jura[1].

The very simple apparatus used for the new method is a slight modification of that described by Haines[2]. The solid is supported on a slate dust or sintered glass membrane sealed into a Buchner funnel, the stem of which is connected to a burette by means of a thick-walled rubber tube. The funnel and burette thus form the two limbs of a *U*-tube. The apparatus is filled with water so that the solid is just saturated, the water-levels in the burette and funnel being the same. Lowering the burette imposes a suction on the sample, and water is withdrawn, its volume being measured from the burette readings. The suction applied is given by the change in water-level. From the results obtained at successive increases in suction, the moisture content of the sample is plotted as a function of suction pressure. Graphical integration then permits calculation of surface area.

Glass spheres of measured sizes were mixed to give known surface areas of 1,800–15,000 sq. cm. per 100 gm.; their moisture content – suction pressure curves were determined and surface areas found from these.

Glass spheres grade	Area (cm.²/100 gm.)	Exp. values	Glass spheres grade	Area (cm.²/100 gm.)	Exp. values
6	1,830	1,650	8+12	5,920	6,480
		1,640			6,370
		1,700		7,590	7,490
		1,640			7,790
6+8	3,120	3,330	12	9,370	9,250
		3,350			10,010
8	4,140	3,950			9,860
		4,040			9,840
		4,170	12+16	11,900	11,730
		3,940			11,450
				14,400	13,410
					13,540
			16	15,600	14,630
					15,240
					14,940

These results were obtained with suctions up to 100 cm. of water, and with no temperature control. Greater accuracy can presumably be attained with more attention to detail, if so desired.

With the finer particles, accuracy has been increased by replacing the air–water interface by benzene–water, with a reduction of interfacial tension from 72·75 to 35·00 ergs per sq. cm. (at 20° C.).

It is hoped to extend the range of the method by working to higher suction pressures, using high-pressure equipment such as the pressure-plate apparatus of Richards[3].

The method may be useful to measure the breakdown of porous materials where the increase in area may be very small compared with the area of the fine pores, since by choosing suitable pressure limits the finer pores remain filled with water and are thus excluded from the area measurement.

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (qualified either in Science (physical or biological) or Mathematics, and with teaching experience) IN THE DEPARTMENT OF EDUCATION—The Registrar, University College of Wales, Aberystwyth (August 15).

SENIOR PHYSICIST (with experience in radiotherapy physics)—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1 (August 22).

LECTURER IN ELECTRICAL ENGINEERING (with good honours degree in electrical engineering and industrial training and experience) at University College, Dundee—The Secretary, The University, St. Andrews (August 24).

KEEPER OF BIOLOGY (with degree in zoology, or botany, or Associate of the Museums Association, with specialization in these subjects)—The Director, City Museum, Park Row, Leeds 1 (August 28).

SCIENTISTS, Grade III (with good honours degree or equivalent qualification in a science subject, and preferably with a sound background in geology and chemistry) at Newcastle-upon-Tyne, Chester, Nottingham and Glasgow, for work on the preparation of detailed reports on the structure and physical and chemical properties of the coal seams covered by these laboratories (Ref. TT/664); CHEMIST, Scientist Grade II or III (with good honours degree or equivalent qualification, and preferably with some research or industrial experience of spectrographic techniques), at Nottingham, for work which will include spectrographic studies of the mineral matter associated with coal (Ref. TT/665); PHYSICIST, Scientist Grade II or III (with good honours degree, and preferably some research experience), at Sheffield, for work which will include studies of the optical properties of coal (Ref. TT/666); SCIENTIFIC TECHNICAL OFFICER, Grade II or Grade III (with good general training in chemistry, preferably to degree standard), at Newcastle-upon-Tyne (Ref. TT/667)—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting appropriate Ref. No. (August 29).

CHEMIST, Assistant Experimental Officer or Experimental Officer Grade (with Higher National Certificate in Chemistry or equivalent qualification) for mineral analysis of plants—The Secretary, East Malling Research Station, Maidstone, Kent (August 31).

PHYSICIST (with aptitude for mathematics and/or mechanical engineering) for theoretical and experimental work on the behaviour of textile fibres during their passage through machinery, and a MATHEMATICIAN (with some or all of the following qualities, (*a*) an aptitude for classical physics, (*b*) a mechanical mind, (*c*) an inclination towards statistics, for work mainly on the behaviour of textile fibres during their passage through machinery—The Director, South African Wool Textile Research Institute, Rhodes University, Grahamstown, South Africa (August 31).

EXPERIMENTAL OFFICER (Ref. F.139/53A), and an ASSISTANT (Scientific) (Ref. F.140/53A) for analytical work related to the Atomic Energy Production programme in establishments at Sellafield (Cumberland), Salwick and Capenhurst—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No. (September 5).

LECTURER IN MECHANICAL ENGINEERING—The Registrar, The University, Sheffield (September 14).

CHAIR OF AERONAUTICAL ENGINEERING at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 15).

READER IN ANTHROPOLOGY at the London School of Economics and Political Science—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 17).

AERONAUTICAL or MECHANICAL ENGINEER (Scientific Officer grade) (with first- or second-class honours degree or equivalent, preferably in aeronautical or mechanical engineering, and sound knowledge of mathematics) in a Ministry of Supply Experimental Establishment near Salisbury, for research, mainly on helicopters, covering investigations on performance, stability and control, operating techniques, and flight-test analysis and associated theoretical studies—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.392/53A.

ASSISTANT LECTURER (Grade B) IN BIOLOGY, in the Department of Chemistry and Applied Chemistry—The Principal, Royal Technical College, Salford 5.

ASSISTANT LECTURER (Grade B) IN PHYSICS (preferably with honours degree in physics, and experience or special interest in applied optics and spectroscopy)—The Principal, North Staffordshire Technical College, Stoke-on-Trent.

ASSISTANT PROFESSOR OF GEOLOGY—Dr. A. A. Duri, Dean, College of Arts and Science, Baghdad, Iraq.

CHEMIST/METALLURGIST (with honours degree in metallurgy or A.I.M. or equivalent, and practical laboratory experience) in the Ministry of Supply at Radway Green, Crewe, for investigation of metallurgical operations and their application to small arms ammunition production and development—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.313/53A.

ELECTRICAL ENGINEERS or PHYSICISTS (with H.S.C. (Science) or equivalent, and experience in electronics) for work on out-of-door instrumentation at Ministry of Supply Experimental Establishments near Southend and Carlisle and take charge of new electronic ballistic instruments and ancillary optical equipment as it is installed, and in conjunction with the designers, prove the equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.191/53A.

ENGINEERS and PHYSICISTS (with first- or second-class honours degree or equivalent in physics or electrical engineering) in the Electronics Division of the Atomic Energy Research Establishment, Harwell, for fundamental research on circuitry and the physics of nuclear radiation detectors, and devising and developing (often in collaboration with industry) electronic devices for Atomic Energy Project—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.195/53A.

PHYSICIST (Experimental Officer grade) (with H.S.C. (Science) or equivalent, and preferably with experience involving advanced metallographic techniques, and knowledge of high vacuum technique and electronics) in a Ministry of Supply Research Establishment in S.E. London, to assist in work involving application of electron microscopy to explosives and metallurgical problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.93/53A.

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